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# EFFECTS OF RVP, $T_{50}$, AND OXYGENATES ON HOT-START AND DRIVEABILITY PERFORMANCE AT HIGH AND LOW ALTITUDE



May 1993





COORDINATING RESEARCH COUNCIL, INC.
219 PERIMETER CENTER PARKWAY, ATLANTA, GEORGIA 30346

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COORDINATING RESEARCH COUNCIL
INCORPORATED
219 PERIMETER CENTER PARKWAY
ATLANTA GEORGIA 30346
(404) 396-3400

# EFFECTS OF RVP, $T_{50}$, AND OXYGENATES ON HOT-START AND DRIVEABILITY PERFORMANCE AT HIGH AND LOW ALTITUDE
## (CRC Project No. CM-118-92)





Prepared by the

CRC Volatility Group

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CRC Automotive Vehicle Fuel, Lubricant, and Equipment Research Committee

of the

Coordinating Research Council, Inc.

## ABSTRACT

A two-phase test program was conducted during July and August 1992 in Longmont, Colorado, and Phoenix, Arizona. The program was designed to investigate the effects of Reid vapor pressure, $T_{50}$, and oxygenates on hot-start and driveability performance of vehicles operated at high and low altitude in high and intermediate ambient temperature ranges. The temperature ranges had means of 70°F and 84°F in Longmont and 99°F in Phoenix. Twenty 1983 - 1992 model-year vehicles were tested on a set of eighteen fuels which included six hydrocarbon-only fuels, six gasoline-ethanol blends, and six gasoline-MTBE blends. Fuel-injected vehicles produced only about one-third the demerits of the carbureted vehicles and were insensitive, in most cases, to $T_{50}$ and the other fuel variables studied. For carbureted vehicles, decreasing $T_{50}$ had no effect with high-RVP fuels, but reduced-$T_{50}$ fuels degraded driveability with low-RVP fuels. In carbureted vehicles, gasoline-oxygenate blends showed generally improved driveability at high altitude with high-RVP fuels. An alternative driveability procedure that emphasized stop-and-go driving showed no significant fuel effects.

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# I. INTRODUCTION

The use of oxygenates in gasoline has been mandated by the US Environmental Protection Agency starting in 1992 for carbon monoxide non-attainment areas and in 1995 for ozone non-attainment areas. When either ethanol or methyl tertiary-butyl ether (MTBE) is added to gasoline, the 50 percent distillation temperature ($T_{50}$) as measured by ASTM Test Method D 86 is reduced significantly, although compensatory changes can be made to the base fuel. In some cases, the $T_{50}$ drops below the minimum limit of 170°F specified in ASTM D 4814, "Standard Specification for Automotive Spark-Ignition Engine Fuel."

ASTM Subcommittee D02.A on Gasoline was asked to review the minimum $T_{50}$ limit in D 4814 and determine whether a lower limit might be appropriate. D02.A then requested that the CRC Volatility Group conduct a hot-start and driveability test program.

The CRC Volatility Group thus conducted a two-phase test program to investigate the effects of Reid vapor pressure (RVP), $T_{50}$, and oxygenates on hot-start and driveability performance of vehicles operated at high and low altitude in three temperature ranges with means of 70°F and 84°F at the high-altitude site and 99°F at the low-altitude site. The high-altitude phase of the program was conducted in Longmont, Colorado, July 7-31, 1992, and the low-altitude phase of the program was conducted in Phoenix, Arizona, August 11 - September 3, 1992.

Members of the Data Analysis Panel and participants in the test program are shown in Appendices A and B, respectively. Appendix C outlines the proposed program as approved by the CRC Volatility Group.

# II. SUMMARY AND CONCLUSIONS

For this test fleet, in the temperature ranges studied, the analysis was handled by partitioning the data set into eight separate cases defined by two levels of ambient temperature, two altitudes, and two levels of RVP (insufficient data were collected in three of the low-altitude cases to obtain meaningful results). The conclusions from this program are:

1. Hot weather driveability malfunctions were sporadic in nature and dependent upon individual vehicles.

2. Overall, fuel-injected vehicles had low mean total weighted demerits (TWD's) and few statistically significant responses to fuel variables; however, decreasing $T_{50}$ caused a small but statistically significant degradation of driveability in the two low-RVP fuel, high-altitude cases. Changes in $T_{50}$, however, had no effect with high-RVP fuels.

3. Fuel-injected vehicles had one-third the TWD levels of carbureted vehicles.

4. Carbureted vehicles generally experienced degraded driveability with increasing ambient temperatures. In more than half the cases, a 10°F increase in ambient temperature had from one to six times the effect on TWD's as a 20°F decrease in $T_{50}$. Because this effect is large, the data and effects should not be extrapolated outside the temperature range studied.

5. For carbureted vehicles at high altitude, no statistically significant effect of $T_{50}$ was found in high-RVP fuels. Insufficient data were available to determine the corresponding response at the low-altitude site.

6. For carbureted vehicles using low-RVP fuel, statistically significant degradation of driveability with decreasing $T_{50}$ was found in most of the cases.

7. For carbureted vehicles using gasoline-MTBE blends, TWD's were statistically significantly lower than for the same vehicles using hydrocarbon-only fuels or gasoline-ethanol blends in the intermediate-temperature, high-altitude, high-RVP case. The TWD's were also statistically significantly lower when the carbureted vehicles used gasoline-MTBE or gasoline-ethanol blends than when they used hydrocarbon-only fuels in the high temperature, high altitude, high-RVP fuel case (gasoline-ethanol and gasoline-MTBE blends were not significantly different).

8. In order to separately treat the cases of practical importance (oxygenated winter and summer gasolines at intermediate temperatures and high altitude, and summer gasolines at high temperatures at high and low altitudes) RVP was used primarily to demarcate cases for independent analysis, rather than being used as a model variable. When RVP was used as a model variable in a separate analysis, increasing RVP degraded driveability by 3 to 5 demerits per psi.

9. Differences in ambient temperatures between test sites preclude any statistical conclusions on altitude effects.

10. While yielding a better correlation of the stall data, the alternative driveability procedure did not yield any significant effects in the analysis of TWD data.

## III. TEST PROGRAM

The test program was conducted in two distinct four-week phases. The high-altitude phase was conducted July 7 through July 31, 1992, and the low-altitude phase was conducted August 11 through September 3, 1992. During the period from August 1 through August 10, the test vehicles, fuels, and equipment were transported from the Colorado test site to the Phoenix site.

The same test vehicle fleet and test fuel set were used at both sites. Because of the daily high maximum temperatures, only one 12-psi fuel was tested for two days in Phoenix. The entire twenty-vehicle test fleet was tested during the first week of both phases using selected fuels. The fleet was then reduced to the most sensitive vehicles, and all remaining testing for that phase was conducted on these vehicles. During the high-altitude phase, at least one representative vehicle of each fuel-system-delivery type was tested. Because several of these representative vehicles were consistently insensitive at the high-altitude test site, they were not tested in the low-altitude phase. Testing in the low-altitude phase concentrated upon sensitive vehicles. As a rule, these sensitive vehicles were tested each day on two separate fuels at high ambient temperatures (above 80°F). During the high-altitude phase, these sensitive vehicles were tested at intermediate ambient temperatures (below 80°F). For most of the high-altitude phase of the program, not all fuels were available from the fuel supplier; therefore, fuel schedules were determined based upon fuel availability and vehicle response.

## A. <u>TEST VEHICLES</u>

The primary criteria for vehicle selection were the technologies of the fuel delivery system and representation of older vehicles in use. In order to accommodate these criteria, the age range of the selected vehicles was extended, including a nine-year-old light-duty truck. Because of the diversity in vehicle ages, the number of miles accumulated prior to testing ranged from 1,000 to 80,000. This range of vehicle ages introduces the attributes of vehicle use and wear as additional conditions potentially influencing the response of the vehicles to the designed test variables.

The test fleet is shown in Table 1. Of the twenty vehicles tested, eleven were 1992 models, two were 1991 models, two were 1986 models, four were 1985 models, and one was a 1983 model. Fourteen of the vehicles were rental vehicles, five were loaned to the program from the Auto/Oil Air Quality Improvement Research Program, and one was loaned by the GMC Zone Office in Colorado. There were fifteen passenger cars and five light-duty trucks. Fuel-delivery systems were divided among six carbureted vehicles, seven port-fuel-injected (PFI) vehicles, five throttle-body-injected (TBI) vehicles, and two central-point-injected (CPI) vehicles.

All vehicles had automatic transmissions. The carbureted vehicles were designated as numbers 1 - 6, the PFI vehicles as numbers 11 - 16 and 24, the TBI vehicles as numbers 21 - 26 except for 24, and the matched pair of CPI vehicles as numbers 31 and 32.

Injected vehicles were prepared for testing by installing Schrader valves in the fuel lines, if they were not so equipped by the manufacturers, in order to facilitate draining the fuel systems. Carbureted vehicles were equipped with fuel tank drains. All of the vehicles began the program in their "as-received" condition, and no additional mechanical work was performed on the vehicles unless it was necessary for the continuance of the test program. At the completion of the program, all drain equipment installed by CRC was removed from the vehicles.

## B. TEST FUELS

The test fuel set contained eighteen fuels. There were six hydrocarbon-only fuels, six 10 volume percent gasoline-ethanol blends, and six 15 volume percent gasoline-MTBE blends. Each compositional group was blended at nominal 7.5 and 12.0 psi Reid vapor pressure (RVP) levels, with three $T_{50}$ values at each RVP level.

The nominal $T_{50}$ values for both the hydrocarbon-only fuels and MTBE blends were 150°F, 170°F, and 190°F; for the gasoline-ethanol blends, the nominal $T_{50}$ values of the hydrocarbon base fuels were 170°F, 190°F, and 210°F. The higher $T_{50}$ values of the gasoline-ethanol blend base fuels were designed to account for the expected drop in $T_{50}$ of approximately 20°F when ethanol is blended into the fuel. Unfortunately, the final gasoline-ethanol blends had lower $T_{50}$ values than expected. The initial target $T_{90}$ of the fuels was 325°F $\pm$ 10°F. Once the fuel supplier selected the $T_{90}$, the tolerance was reduced to $\pm$5°F.

All fuels were required to have a minimum (R+M)/2 octane rating of 90. Aromatics were limited to a maximum of 32 volume percent and benzene was limited to a maximum of 1 volume percent. Antioxidants and corrosion inhibitors were required in all fuels.

Once blended, samples of the test fuels were analyzed by the fuel supplier and individual participating laboratories. Four laboratories submitted analyses of the test fuels. Average fuel properties are presented in Table 2; individual laboratory fuel properties are summarized in Appendix D. Average $T_{50}$ ranged from 141°F to 152°F for the low-$T_{50}$ fuels, 159°F to 172°F for the mid-$T_{50}$ fuels, and 176°F to 195°F for the high-$T_{50}$ fuels. Outliers were rejected using ASTM guidelines prior to the calculation of average values.

## C. FUEL HANDLING PROCEDURE

No testing was conducted during the infrequent periods of rainfall. Vehicles were refueled from drums containing the test fuels via dispensing pumps installed in the drums. The drums were shielded from direct sun via canopies or reflective covers. Additionally, when required, drums were given a burlap cover and frequently wet with water to provide evaporative cooling.

The API gravity of the fuel in several drums was measured on site to ensure fuel integrity. Table 3 shows the values measured at each site. Because the values were not significantly different from initial inspection data, fuel handling procedures were judged to be adequate, and further extensive sampling was discontinued, although spot-checks were made.

## D. TEST TEMPERATURES

The mean test temperatures at both sites are presented below:

High-Altitude

| High-RVP | | Low-RVP | |
|---|---|---|---|
| High-Temp. | Intermediate-Temp. | High-Temp. | Intermediate-Temp. |
| 84.4°F | 69.7°F | 84.3°F | 73.8°F |

Low-Altitude

| Low-RVP | |
|---|---|
| High-Temp. | Intermediate-temp |
| 99.0°F | 87.7°F |

The demarcation temperature between high- and intermediate-temperature testing is 80°F at high altitude and 90°F at low altitude.

## E. TEST FACILITIES

The high-altitude phase of the program was conducted at the Mountain View Motor Sports Park in Longmont, Colorado, north of Denver, at an altitude of 5,050 feet. The track facility offers two road courses; the 1.2-mile, level, paved circuit with a half-mile straightaway was used. A schematic of the track as used is shown in Figure 1.

The low-altitude phase of the program was conducted at Failure Analysis Associates in Phoenix, Arizona, at an approximate altitude of 1,000 feet. The track is a 2-mile, level, paved oval. A schematic of the track is shown in Figure 2.

Additional facilities at both locations included inside office accommodations, fuel storage area, equipment storage area, fuel tank drain area, access to local roads and expressway for preconditioning of the vehicles, and accommodations immediately adjacent to the tracks for a three-vehicle soak shelter. In Phoenix, a refrigerated shipping container was used to maintain the fuel temperatures at approximately 70°F due to the high ambient temperatures experienced in Phoenix during August.

## F. DRIVEABILITY PROCEDURES

The driveability procedures were developed specifically for this program. A generalized test procedure is included in the program proposal detailed in Appendix C. Specific instructions for preconditioning and logistics, developed on-site at each location, are detailed in Appendices E and F. An additional test procedure used at the end of the low-altitude testing is given in Appendix G. This additional test procedure was a first attempt to improve vehicle response for better discrimination among fuels.

The driveability test procedure began with adding the prescribed amount of test fuel to an empty tank, and preconditioning the adaptive memory while warming-up the vehicle to operating temperature. The 15-mile warm-up/preconditioning procedure included steady states of 5, 15, 25, and 35 miles per hour for a minimum of 30 seconds each, at least one full stop with a light-throttle acceleration, and 65 miles per hour or legal speeds for the remainder. If the rating team was not available to begin testing the vehicle upon return to the test area, the vehicle was idled for one minute and then laps of the test track were completed until the rating team became available. When the rating team was available, the engine was turned off for one minute, and restarted by the rating team. Immediately upon completion of the test, the fuel tank was drained in preparation for the next test. The test procedure consisted of eight idle periods, two nominal 0-60 mile-per-hour wide-open-throttle accelerations, seven 0-5 mile-per-hour light-throttle accelerations, two hot-starts and one twenty-minute engine-off soak in the soak shelter. Hesitations, stumbles, surges, stalls, and backfires were rated during each of the accelerations, as well as engine roughness during the idle periods. Each was rated as trace, moderate or heavy; the number of stalls were recorded. Driveability malfunctions were recorded for the series of engine idles, accelerations and decelerations; these malfunctions appear as demerits in Appendix H.

The test procedure outlined in Appendix C was used throughout the high-altitude testing and during most of the low-altitude testing. Because there was some concern that this was the first time this test procedure had been used, and there was thus no reference point upon which to judge its success at evaluating vehicle/fuel performance, and because of the desire to thoroughly investigate all possible vehicle/fuel operation deficiencies, a second test procedure was developed toward the end of the low-altitude testing. The second procedure is presented in Appendix G, and consisted of five additional idle periods, one additional nominal 0-60 mile-per-hour wide-open-throttle acceleration, three additional 0-5 mile-per-hour light-throttle accelerations, three new 0-25 mile-per-hour light-throttle accelerations, and one new ten-minute idle soak in drive in the soak shelter. A comparison of the two driveability procedures is presented below. It should be noted that the sequence of the maneuvers is important to the severity of the test. Complete details of the procedures are given in Appendices C and G. Malfunctions appear as demerits at the end of Appendix H.

COMPARISON OF TEST PROCEDURES

| | Maneuver Count within a Test Procedure | | |
| --- | --- | --- | --- |
| Maneuver | Driveability Procedure | Alternate Driveability Procedure | Change |
| Hot Start | 2 | 2 | 0 |
| Soak | 1 | 1 | 0 |
| Idle | 8 | 13 | +5 |
| WOT | 2 | 3 | +1 |
| 0-5 LT | 7 | 10 | +3 |
| 0-25 LT | 0 | 3 | +3 |
| Idle Soak | 0 | 1 | +1 |

## IV. ANALYTICAL METHODS

The data were analyzed using the SAS (c) statistical system. All individual maneuver variables were badly skewed and non-normal; however, TWD's were normally distributed and suitable for analysis with General Linear Models (GLM). The formula for calculating TWD is given in Appendix I. Vehicle base demerit level, and temperature correction were handled by using temperature and vehicle nested within fuel system as model variables. Vehicle-to-vehicle variation was large, and there was significant test to test variation in the response of some of the vehicles. Temperature was often a significant variable and had a powerful effect on driveability. Raters did not exchange vehicles frequently, so it was not possible to obtain valid rater correction factors for this data set.

The vehicles were analyzed as subsets: carbureted and injected. The mean demerit level is very different in these two groups. The data were further parsed into eight cases of interest:

| CASE | ALTITUDE | TEMPERATURE | RVP |
| --- | --- | --- | --- |
| 1 | High | Intermediate | Low |
| 2 | High | High | Low |
| 3 | Low | High | Low |
| 4 | High | Intermediate | High |
| 5 | High | High | High |
| 6 | Low | Intermediate | Low |
| 7 | Low | High | High |
| 8 | Low | Intermediate | High |

At high altitude, the break between high and intermediate temperature was taken as 80°F, while it was take as 90°F at low altitude. The difference reflects the fact that fuel vaporization occurs to a greater extent at higher altitude.

In most of the analyses RVP was used to define cases, not as a variable. Comparisons of results in the high-RVP and low-RVP cases are made, but the actual fuel set is sufficiently nonorthogonal to complicate using RVP as a variable in the model. Further analysis was done using RVP as a model variable. The case-by-case analysis conforms better to the scenarios of practical interest for model effects other than RVP.

The same analysis methods were used in treating the alternate driveability procedure (R2) data; however, the R2 method was only used at low altitude. In order to compare the driveability procedure with the alternate driveability procedure, the high-temperature data at low altitude were also analyzed after removing sufficient data to make the data sets comparable in size. This was done by sorting the data by vehicle and fuel and then removing a data point at regular intervals. This was done four times with different starting points in order to check that no bias was introduced.

In all case results, the minimum level for statistical significance was 90 percent (probability of greater $|T| \leq 0.10$). Each of the temperatures used in the analysis is the mean of the three temperatures measured at the beginning, at the end, and during the soak period of that driveability test.

Unless noted otherwise, the following discussion refers to the main (standard CRC hot-start and driveaway) driveability procedure data set. All references to the alternate driveability procedure will be specifically noted.

The data were analyzed using TWD, square root of TWD, natural log of TWD, and a scale defined as the <u>O</u>ccurrence of <u>M</u>ajor (Driveability) <u>M</u>alfunctions, OMM (see Appendix I). Analysis using the log of TWD gave poorer data correlation as measured by the r-square of the correlation. Analysis using TWD and square root of TWD gave equivalent r-square. Because TWD has clear physical meaning, only TWD, R2, and OMM analysis are discussed in the body of the report. Results based on the square root of TWD were quite similar to those based on TWD. Tables of square root of TWD results are provided in Appendix J.

## V. DISCUSSION OF RESULTS

### A. Carbureted Vehicles

The effect of $T_{50}$ at the oxygenate levels studied is generally significant for low-RVP fuels with driveability being degraded roughly 15 percent of the mean demerit level by a 20°F decrease in $T_{50}$. For high-RVP fuels, $T_{50}$ was not a statistically significant model effect. Increasing ambient temperature caused statistically significant degradation of driveability in several cases. A 10°F change in temperature had from 1 to 6 times the effect of a 20°F change in $T_{50}$. One or both oxygenates improved driveability in the high-altitude / high-RVP cases, but oxygenates had no significant effect in the low-RVP cases. Case-by-case details follow.

#### LOW RVP FUELS

Case 1, Low-RVP fuel at intermediate temperature and high altitude
The driveability of carbureted vehicles degraded as the $T_{50}$ of the fuel decreased in tests conducted at the Denver site with 7.5 psi RVP fuel at temperatures below 80°F (see figure 3). This result, based on a total of 88 tests with 6 vehicles and 9 fuels, was statistically significantly different from the null case at the 99 percent confidence level. The $r^2$ of the regression was 0.77. None of the other variables tested (ambient temperature, MTBE content, ethanol content, rater) were significant at the 90 percent confidence level. These results are summarized in the first line of Table 4. The mean level of demerits in this case is 45, with an increase of 6.5 demerits for every 20°F decrease in $T_{50}$, approximately 15 percent of the mean level.

Case 2, Low-RVP fuel at high temperature and high altitude
At the higher temperatures covered in Figure 4 and line 2 of Table 4, the carbureted vehicles again experienced degraded driveability at lower $T_{50}$. This case represents the use of summer fuels in summer weather at high altitude. The mean demerit level for the 57 tests is higher than in the intermediate temperature case, reflecting the fact that overall driveability was slightly poorer above 80°F than below, even though ambient temperature is not a statistically significant variable in either low RVP case at high altitude. A 20°F decrease in $T_{50}$ resulted in a 8.6 demerit increase in TWD's, again 15 percent of the mean level. The 10.5°F higher mean ambient temperature in the high temperature case is accompanied by a relatively small 10.5 demerit increase in mean TWD's, relative to the intermediate temperature case.

Case 3, Low-RVP fuels at high temperature and low altitude

In the summer fuel/ summer weather case at low altitude both ambient temperature and $T_{50}$ had statistically significant affects on the driveability of low RVP fuels. The results of the 102 tests are summarized in line 3 of Table 4. Ambient temperature clearly had greater impact, a 31.3 demerit increase in TWD's for a 10$^{o}$F rise in ambient temperature, while a 5.5 demerit increase in mean TWD's was observed when $T_{50}$ was decreased by 20$^{o}$F. The overall mean level of TWD's was 70.5 demerits so the $T_{50}$ effect is slightly greater than 7.5 percent of the mean (see Figure 5). Because of the poor overlap in temperature between the two phases of the program, formal regression analysis was not attempted with altitude as a variable.

Other Observations with Low-RVP Fuels

There were no significant effects for the case of low altitude and intermediate temperature. This is probably due to the very small amount of data collected in that case (only 16 tests); it should not be taken to mean that there are or are not physically important influences of fuel variables in that case.

Oxygenates were not a statistically significant variable in any low-RVP fuel case.

## HIGH RVP FUELS

Case 4, High-RVP Fuels at high altitude and intermediate temperature

This intermediate temperature/high-RVP case represents the situation of winter fuels used during winter warm snaps at high altitude. It is of special interest in areas such as Denver, Colorado, and Albuquerque, New Mexico, that use oxygenates to reduce CO emissions during the winter months. MTBE blends were a statistically significant model effect (92 percent confidence) for high-RVP fuels. In the 62 tests at high altitude and intermediate temperatures, MTBE-blended fuels caused carbureted vehicles to accrue 8.5 fewer demerits than they did with hydrocarbon fuels (see line 4 of Table 4). The magnitude of this difference is 15 percent of the mean TWD level, 52 demerits. Ethanol blends were not significantly different from hydrocarbon fuels. The reason both types of oxygenated fuels did not behave similarly in these tests is not understood.

Ambient temperature was also a statistically significant model variable. A 10$^{o}$F increase in ambient temperature resulted in a 25 demerit (50 percent relative to the mean) increase in TWD's. At high altitude $T_{50}$ was not statistically significant in tests of high-RVP fuels at high altitude. This is illustrated in Figure 6, as well as line 4 of Table 4.

Case 5, High-RVP fuel at high altitude and high temperature

When high-RVP fuels were tested in carbureted vehicles at high temperatures, a mean of 78.5 demerits was found over 45 tests. Hydrocarbon fuels caused an average of 17 more demerits than MTBE-blended fuels (see line 5 of Table 4). The magnitude of this difference was also roughly 15 percent of the mean. In addition to the significant difference between MTBE-blends and hydrocarbon-only fuels, both Means and least square (LS) Means options in the GLM analysis showed that hydrocarbon fuels also performed more poorly than ethanol blends at the 95 percent confidence level. The magnitude of the effect was also 17 demerits. The 10 percent ethanol blends were not significantly different from the 15 percent MTBE blends in this case.

Ambient temperature was again a statistically significant model variable. A $10^{O}F$ increase in ambient temperature resulted in a 30 demerit increase in TWD's (40 percent relative to the mean). At high altitude, $T_{50}$ was not statistically significant in tests of high-RVP fuels. This is illustrated in Figure 7, as well as line 5 of Table 4.

Only 15 tests on carbureted vehicles and a total of 30 tests on all vehicles were conducted for the case of high-RVP fuels at low altitude. These were insufficient data to obtain statistically significant results relative to $T_{50}$ or any other model effect.

## ALTERNATE TESTS AND ANALYSIS

Regression of the 94 tests run at low altitude using the alternative procedure (R2) did not yield any significant effects in TWD, as shown in lines 1 and 2 of Table 5. In order to determine if this null result was due to the smaller data-set size, the low-altitude, low-RVP, high-temperature case from the main driveability procedure was pared down to 68 carbureted vehicle observations, a subset of similar size to the 63 carbureted vehicle observations in the R2 data set. Subsetting was done four different ways, with each subset retaining some data from each vehicle. Every data point from the full data set appeared in at least one subset. In each case, the correlation constant of the subset was comparable to the correlation constant prior to subsetting, and was better than the correlation of the R2 data set. Furthermore, significant effects for temperature and $T_{50}$ were obtained. It would appear that the main driveability procedure does a better job of sorting fuels than the R2 procedure.

The correlation of stall data with the model variables was better for the R2 procedure (0.40) than for the main driveability procedure (0.24). These data will inherently have poor correlation because there are many zeros with occasional incidences of one or more stalls. The effect of a $20^{O}F$ decrease in $T_{50}$ on stalls is large, similar in magnitude to the mean in tests on carbureted vehicles and half the magnitude of the mean for all vehicles taken together. For this reason, the R2 procedure is still of value. The R2 method emphasizes start and stop maneuvers after hot soak but before any heavy acceleration. It is, therefore, especially sensitive to fuel restriction due to vapor in the fuel-delivery system.

Results of the final method of analyzing the main driveability procedure data, the OMM scale which measures only major malfunctions, are presented in Table 6. The correlations are intermediate between those of the stall analysis and the full TWD analysis. The model effects are similar to those in the TWD analysis, but the magnitudes are larger relative to the means. For example the increase in OMM due to a 20$^{o}$F decrease in $T_{50}$ is roughly 40 percent of the mean, while 10$^{o}$F temperature increases cause increases in OMM from 50 to 100 percent of the mean level. It would appear that the incidence of major malfunctions responds to fuel and environmental variables in the same ways as TWD do, but at a greater level of response, and with poorer correlation.

## RVP

It is possible to test RVP as a model variable rather than using it to distinguish the real world cases of summer and winter fuel. As has been shown above, there are substantial differences in the behavior of the test fleet with the high- and low-RVP fuels at high altitude. The danger in treating RVP as a model variable is that these disparate results in temperature and $T_{50}$ must be forced into a common trend. Both the magnitude of the effects and the chance they will be statistically significant are reduced. Furthermore, because the span of $T_{50}$ in the delivered fuel set was not the same at high and low RVP for a given oxygenate type, the data set is not well suited to multidimensional regression analysis. Nevertheless, it is the most unbiased way to attempt to look at the effect of RVP, even though it will distort the $T_{50}$ and temperature effects.

The GLM analysis including RVP does in fact show reduced magnitude and significance for $T_{50}$, ambient temperature, and oxygenates. The trends are magnified if the ethanol data (which were very poorly distributed in $T_{50}$ when high and low RVP are taken together) are deleted. For the reasons stated above, the results in Tables 4 through 6 are considered the best estimates of these effects. The effect of RVP was to increase TWD by 3-5 demerits for each PSI increase in RVP. RVP was more influential at high temperature. These are the relevant results from the GLM analysis including RVP as a model effect; the results are summarized in Table 7. RVP analysis was not done at low altitude, because so little data are available for the high-RVP fuels.

## B. Fuel Injected Vehicles

Fuel injected vehicles had on average one third the demerits of their carbureted counterparts (see Figure 8 and Table 8). As expected at this low level of response, the data were much noisier relative to the mean. The root mean square error was as much as 83 percent of the mean, compared to 30 percent of the mean for carbureted vehicles. No statistically significant effects were observed at low altitude. The correlations are generally worse than those found in the analysis of the carbureted vehicle data, and when good correlations are found, there are no significant model effects. In the OMM analysis the correlations were even worse, and so it is not clear that the effects labeled as significant in

the model are important in reality. No significant model effects were identified for the four fuel injected vehicles tested with the R2 procedure.

Overall, this program revealed only a minor response among fuel-injected vehicles, though stalls and heavy malfunctions did occur on infrequent occasions. Still, these infrequent malfunctions could be important to customers.

Low-RVP fuel at high altitude: Cases 1 and 2

The driveability of low-RVP fuels in fuel-injected vehicles was qualitatively similar to that observed in carbureted vehicles: $T_{50}$ was the only significant effect and the magnitude of the effect was 15 to 30 percent of the mean. The means were much lower, however, so the effects were also very small, 2 to 4 demerits per 20°F reduction in $T_{50}$. Oxygenates were not statistically significant. Lines 1 and 2 of Table 8 summarize the results. The OMM results (Table 9, lines 1 and 2) do not parallel those of the carbureted vehicles. Only temperature is significant, but the $r^2$ for the correlation is very low.

High-RVP fuels at high altitude: Cases 4 and 5

The only significant effect was ambient temperature in the low-temperature case (see Table 8, line 4 ). The effect was to degrade driveability by roughly half the mean value when temperature increased by 10°F. Oxygenates were not significant model effects. In the OMM analysis (Table 9, line 4) temperature was also important, but again the $r^2$ is quite low, and it is not clear there is any physical meaning to the effect.

TABLES

AND

FIGURES

TABLE 1
TEST VEHICLES

| Year | Make/Model | Displacement (liters) | Initial Odometer (miles) | Fuel System |
|---|---|---|---|---|
| 1983 | Ford F150 Truck | 4.9 | 65040 | Carbureted |
| 1985 | Honda Accord | 1.8 | 80930 | Carbureted |
| 1985 | Plymouth Reliant | 2.2 | 53170 | Carbureted |
| 1986 | Dodge Colt | 1.5 | 80710 | Carbureted |
| 1985 | Chevrolet Impala | 5.0 | 50810 | Carbureted |
| 1986 | Plymouth Grand Fury | 5.2 | 23115 | Carbureted |
| 1991 | Oldsmobile Cutlass Ciera | 3.3 | 27585 | Port-Fuel-Injected |
| 1992 | Nissan Sentra | 1.6 | 16220 | Port-Fuel-Injected |
| 1992 | Toyota Camry LE | 2.2 | 1225 | Port-Fuel-Injected |
| 1992 | Ford Tempo | 2.3 | 3440 | Port-Fuel-Injected |
| 1992 | Pontiac Gran Prix LE | 3.1 | 7845 | Port-Fuel-Injected |
| 1992 | Plymouth Voyager Van | 3.3 | 7170 | Port-Fuel-Injected |
| 1992 | Mercury Grand Marquis | 4.6 | 1025 | Port-Fuel-Injected |
| 1985 | Ford Tempo | 2.3 | 55570 | Throttle-Body-Injected |
| 1991 | Chevrolet Cavalier | 2.2 | 13255 | Throttle-Body-Injected |
| 1992 | Geo Metro | 1.0 | 11190 | Throttle-Body-Injected |
| 1992 | GMC Safari Van | 4.3 | 2270 | Throttle-Body-Injected |
| 1992 | Chevrolet Caprice Classic | 5.0 | 11350 | Throttle-Body-Injected |
| 1992 | GMC Jimmy | 4.3 | 3645 | Central-Point-Injected |
| 1992 | GMC Jimmy | 4.3 | 2700 | Central-Point-Injected |

## TABLE 2

### TEST FUEL PROPERTIES

| Fuel | 1 | 3 | 5 | 7 | 9 | 11 | 13 | 15 | 17 |
|---|---|---|---|---|---|---|---|---|---|
| API Grav | 68.0 | 70.0 | 63.3 | 63.7 | 62.1 | 60.5 | 66.4 | 62.1 | 62.4 |
| Composition (volume %) | | | | | | | | | |
| Aromatics | 9.4 | 13.6 | 24.0 | 22.2 | 23.4 | 25.4 | 19.0 | 27.2 | 25.2 |
| Olefins | 0.4 | 0.5 | 0.4 | 0.8 | 0.8 | 0.6 | 0.5 | 0.4 | 0.5 |
| Saturates | 80.2 | 86.0 | 75.6 | 77.1 | 75.8 | 76.6 | 80.6 | 72.4 | 76.9 |
| Benzene | - | 0.13 | 0.30 | - | 0.15 | 0.27 | 0.23 | 0.10 | 0.50 |
| MTBE | - | - | - | - | - | - | 14.5 | 14.6 | 14.9 |
| Ethanol | - | - | - | 9.5 | 8.8 | 9.8 | - | - | - |
| RVP (psi) | 7.4 | 7.5 | 7.5 | 7.9 | 7.1 | 7.7 | 7.6 | 7.6 | 7.2* |
| Distillation (°F), % Evaporated | | | | | | | | | |
| $T_{10}$ | 132 | 131 | 130 | 127 | 132 | 132 | 131 | 126 | 132 |
| $T_{20}$ | 137 | 139 | 143 | 131 | 137 | 138 | 135 | 134 | 143 |
| $T_{30}$ | 141 | 147 | 156 | 134 | 142 | 144 | 139 | 141 | 154 |
| $T_{40}$ | 146 | 155 | 174 | 138 | 147 | 152 | 143 | 150 | 168 |
| $T_{50}$ | 152 | 165 | 195 | 143 | 172 | 182 | 147 | 164 | 185 |
| $T_{60}$ | 160 | 178 | 222 | 167 | 206 | 217 | 155 | 186 | 209 |
| $T_{70}$ | 177 | 203 | 253 | 206 | 239 | 243 | 169 | 233 | 238 |
| $T_{80}$ | 237 | 247 | 292 | 264 | 282 | 277 | 215 | 292 | 272 |
| $T_{90}$ | 323 | 318 | 332 | 327 | 337 | 324 | 326 | 334 | 316 |
| RON | 90.5 | - | - | 97.0 | 97.3 | 98.8 | 95.2 | - | 97.9 |
| MON | 86.2 | - | - | 89.2 | 89.8 | 89.8 | 88.8 | - | 90.1 |
| (R+M)/2 | 88.4 | - | - | 93.0 | 93.6 | 94.4 | 92.0 | - | 94.0 |
| $T_{V/L=20}$* (°F) | 142 | 143 | 153 | 131 | 137 | 135 | 134 | 139 | 144 |

* Single determinations by a single laboratory

**TABLE 2 - (Continued)**

**TEST FUEL PROPERTIES**

| Fuel | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
|---|---|---|---|---|---|---|---|---|---|
| API Grav | 70.8 | 72.5 | 66.0 | 65.4 | 65.8 | 63.4 | 66.3 | 63.5 | 64.7 |
| Composition (volume %) | | | | | | | | | |
| Aromatics | 17.3 | 13.2 | 21.4 | 20.7 | 18.3 | 23.3 | 23.1 | 25.6 | 20.3 |
| Olefins | 0.5 | 0.5 | 0.4 | 0.8 | 0.8 | 0.5 | 0.7 | 0.5 | 0.6 |
| Saturates | 82.3 | 88.1 | 78.2 | 78.8 | 80.9 | 76.3 | 76.1 | 73.9 | 79.1 |
| Benzene | - | 0.10 | 0.25 | - | 0.15 | 0.30 | 0.15 | 0.30 | 0.50 |
| MTBE | - | - | - | - | - | - | 13.0 | 15.0 | 13.7 |
| Ethanol | - | - | - | 9.1 | 8.2 | 9.1 | - | - | - |
| RVP (psi) | 11.4 | 11.6 | 11.4 | 11.3 | 11.7 | 11.6 | 11.8 | 11.6 | 11.4 |
| Distillation (°F), % Evaporated | | | | | | | | | |
| $T_{10}$ | 112 | 110 | 107 | 114 | 113 | 114 | 108 | 107 | 109 |
| $T_{20}$ | 123 | 125 | 121 | 123 | 125 | 128 | 119 | 121 | 125 |
| $T_{30}$ | 133 | 137 | 137 | 129 | 134 | 139 | 128 | 134 | 141 |
| $T_{40}$ | 141 | 149 | 158 | 135 | 142 | 147 | 138 | 150 | 158 |
| $T_{50}$ | 149 | 161 | 188 | 141 | 159 | 179 | 151 | 170 | 176 |
| $T_{60}$ | 158 | 174 | 218 | 156 | 193 | 212 | 167 | 198 | 200 |
| $T_{70}$ | 174 | 196 | 248 | 195 | 228 | 238 | 203 | 237 | 230 |
| $T_{80}$ | 253 | 240 | 286 | 255 | 275 | 274 | 273 | 284 | 265 |
| $T_{90}$ | 331 | 316 | 329 | 322 | 333 | 322 | 326 | 332 | 312 |
| RON | 90.8 | - | - | 96.8 | 97.1 | 98.2 | 98.2 | 99.5 | 97.4 |
| MON | 86.7 | - | - | 89.2 | 89.9 | 90.2 | 90.5 | 91.2 | 90.7 |
| (R+M)/2 | 88.8 | - | - | 92.7 | 93.5 | 94.2 | 94.4 | 95.3 | 94.1 |
| $T_{V/L=20}$* (°F) | 120 | 120 | 122 | 117 | 117 | 117 | 113 | 113 | 121 |

* Single determinations by a single laboratory

# TABLE 3

1992 CRC HOT WEATHER DRIVEABILITY TESTS
TEST-FUEL SAMPLES FOR API GRAVITY
FUEL SAMPLES AT TEST SITES

| DATE | TIME | FUEL # | API GRAV. AVG. ANALYSIS (LABS) | OBS. GRAVITY | OBS. FUEL TEMP.,F | API GRAVITY @ 60 F | % DIFF. | SAMPLE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| | | | | | DENVER | | | |
| 07/16/92 | 08:15 | VF-8 | 65.4 | 67.2 | 66 | 66.4 | | After 1st car fill (fresh drum) |
| 07/16/92 | 12:22 | VF-8 | 65.4 | 67.7 | 69 | 66.5 | 0.15 | After last car fill (~1/4 full drum) |
| 07/16/92 | 08:30 | VF-14 | 66.8 | 67.6 | 68 | 66.6 | | After 1st car fill (fresh drum) |
| 07/16/92 | 12:00 | VF-14 | 66.8 | 67.7 | 68 | 66.4 | -0.30 | After last car fill (empty drum) |
| 07/16/92 | 12:05 | VF-14 | 66.8 | 67.3 | 66 | 66.5 | | 2nd drum, after 1st car fill (fresh drum) |
| 07/16/92 | 12:40 | VF-2 | 70.8 | 71.4 | 64 | 70.8 | | After 1st car fill (fresh drum) |
| 07/16/92 | 14:45 | VF-2 | 70.8 | 72.2 | 70 | 70.8 | 0.00 | After last car fill (empty drum) |
| 07/17/92 | 07:31 | VF-6 | 66.3 | 66.2 | 61 | 66.1 | | After 1st car fill (fresh drum) |
| 07/17/92 | 09:15 | VF-6 | 66.3 | 66.9 | 68 | 65.9 | -0.30 | After last car fill (empty drum) |
| 07/17/92 | 09:40 | VF-12 | 63.4 | 64.7 | 70 | 63.5 | | After 1st car fill (fresh drum) |
| 07/17/92 | 11:05 | VF-12 | 63.4 | 65.1 | 74 | 63.4 | -0.16 | After last car fill (~1/5 drum) |
| 07/17/92 | 09:45 | VF-6 | 66.3 | 68.1 | 76 | 66.0 | | After 1st car fill (fresh drum) |
| 07/17/92 | 11:15 | VF-6 | 66.3 | 68.6 | 78 | 66.2 | 0.30 | After last car fill (~3/4 drum) |
| | | | | | PHOENIX | | | |
| 08/11/92 | 13:50 | VF-5 | 63.3 | 68.2 | 100 | 63.2 | | After last car fill (empty drum) |
| 08/11/92 | 14:00 | VF-1 | 68.0 | 74.2 | 105 | 68.0 | | After last car fill (empty drum) |
| 08/12/92 | 12:45 | VF-1 | 68.0 | 72.8 | 95 | 68.0 | | After last car fill (~1/5 drum) |
| 08/12/92 | 14:07 | VF-2 | 70.8 | 76.5 | 100 | 70.8 | | After last car fill (~1/2 drum) |
| 08/13/92 | 13:16 | VF-7 | 63.7 | 68.9 | 100 | 63.8 | | After last car fill (~1/5 drum) |
| 08/13/92 | 13:23 | VF-13 | 66.4 | 69.4 | 99 | 64.4 | | After last car fill (~1/5 drum) |
| 08/17/92 | 12:30 | VF-7 | 63.7 | 68.6 | 98 | 63.7 | | After last car fill (empty drum) |
| 08/17/92 | 12:40 | VF-13 | 66.4 | 68.7 | 94 | 64.3 | | After last car fill (empty drum) |
| 08/18/92 | 08:05 | VF-11 | 60.5 | 63.3 | 82 | 60.7 | | Fresh drum, before 1st car fill |
| 08/18/92 | 13:40 | VF-11 | 60.5 | 64.7 | 94 | 60.6 | -0.16 | After last car fill (empty drum) |
| 08/18/92 | 08:10 | VF-17 | 62.4 | 65.2 | 82 | 62.8 | | Fresh drum, before 1st car fill |
| 08/20/92 | 09:05 | VF-17 | 62.4 | 65.2 | 82 | 62.5 | | Fresh drum, before 1st car fill |
| 08/20/92 | 12:45 | VF-17 | 62.4 | 66.6 | 92 | 62.6 | 0.16 | After last car fill (empty drum) |
| 08/20/92 | 09:11 | VF-11 | 60.5 | 63.3 | 82 | 60.7 | | Fresh drum, before 1st car fill |
| 08/20/92 | 13:20 | VF-11 | 60.5 | 64.7 | 94 | 60.6 | -0.16 | After last car fill (empty drum) |

TABLE 4

# TWD by RVP and Altitude for Carbureted Vehicles

| Altitude | Temperature ($^{o}F$) | RVP (psi) | Significant effects | Magnitude of effect (TWD) | Mean (TWD) | RMSE[1] (TWD) | Confidence level | $r^2$ for correlation |
|---|---|---|---|---|---|---|---|---|
| high | ≤80 | 7.5 | $T_{50}$ | $-6.5/20^{o}F$[2] | 45.2 | 16.8 | 99% | 0.77 |
| high | ≥80 | 7.5 | $T_{50}$ | $-8.6/20^{o}F$ | 55.7 | 16.5 | 99% | 0.76 |
| low | ≥90 | 7.5 | Temperature<br>$T_{50}$ | $31.3/10^{o}F$[3]<br>$-5.5/20^{o}F$ | 70.5 | 23.2 | 99.99%<br>95% | 0.82 |
| high | ≤80 | 11.5 | Temperature<br>Oxygenate | $25.2/10^{o}F$<br>8.5 HC/MTBE[4] | 51.6 | 14.5 | 99.99%<br>92% | 0.79 |
| high | ≥80 | 11.5 | Temperature<br>Oxygenate | $30.3/10^{o}F$<br>17.5 HC[5] | 78.5 | 19.9 | 99%<br>96% | 0.70 |

[1] Root mean square error
[2] Indicates that driveability improves with increasing $T_{50}$
[3] Indicates that driveability degrades with increasing ambient temperature
[4] Indicates that hydrocarbon only fuels perform worse than 15% MTBE fuels, but are not different from 10% ethanol blends
[5] Indicates that hydrocarbon only fuels perform worse than both 15% MTBE and 10% ethanol blends

TABLE 5

# Results from Alternative Driveability Procedure

| Vehicles and variables | Significant effects | Magnitude of effect (TWD) | Mean (TWD) | RMSE[1] (TWD) | Confidence level | $r^2$ for correlation |
|---|---|---|---|---|---|---|
| TWD in carburetted vehicles | none | | 15.84 | 6.2 | | 0.63 |
| TWD in injected vehicles 11, 21, 23, 24 | none | | 19.3 | 7.2 | | 0.56 |
| TWD from stalls in carburetted vehicles | $T_{50}$ | $-4.8/20^{o}F$[2] | 5.0 | 10. | 98% | 0.40 |
| TWD from stalls in all vehicles | $T_{50}$ | $-3.4/20^{o}F$ | 5.9 | 11. | 99% | 0.37 |

[1] Root mean square error
[2] Indicates that driveability improves with increasing $T_{50}$

TABLE 6

# Occurrence of Major Malfunctions by RVP and Altitude for Carbureted Vehicles

| Altitude | Temperature ( $^0$F) | RVP (psi) | Significant effects | Magnitude of effect (TWD) | Mean (TWD) | RMSE[1] (TWD) | Confidence level | $r^2$ for correlation |
|---|---|---|---|---|---|---|---|---|
| high | ≤80 | 7.5 | $T_{50}$ | -0.51/20$^o$F[2] | 1.26 | 1.39 | 98% | 0.56 |
| high | ≥80 | 7.5 | $T_{50}$ | -0.56/20$^o$F | 1.44 | 1.05 | 99% | 0.70 |
| low | ≥90 | 7.5 | Temperature<br>$T_{50}$ | 2.8/10$^o$F[3]<br>-0.85/20$^o$F | 2.87 | 2.65 | 99.99%<br>95% | 0.54 |
| high | ≤80 | 11.5 | Temperature | 1.4/10$^o$F | 1.54 | 1.22 | 99.99% | 0.57 |
| high | ≥80 | 11.5 | Temperature<br>Oxygenate | 1.5/10$^o$F<br>-1.7 MTBE[4] | 3.18 | 1.51 | 96%<br>99% | 0.61 |

[1] Root mean square error
[2] Indicates that driveability improves with increasing $T_{50}$
[3] Indicates that driveability degrades with increasing ambient temperature
[4] Indicates that 15% MTBE fuels perform better than hydrocarbon fuels or 10% ethanol blends

TABLE 7

# RVP Effects in Carbureted Vehicles

| Altitude | Temperature ( $^0$F) | Significant effects | Magnitude of effect (TWD) | Mean (TWD) | RMSE[1] (TWD) | Confidence level | $r^2$ for Correlation |
|---|---|---|---|---|---|---|---|
| high | ≤80 | Temperature<br>$T_{50}$<br>RVP | 15.2/10$^o$F[2]<br>-3.7/20$^o$F[3]<br>3.2/psi[4] | 47.8 | 16.8 | 99.99%<br>96%<br>99.99% | 0.73 |
| high | ≥80 | Temperature<br>$T_{50}$<br>RVP | 16.7/10$^o$F<br>-6.0/20$^o$F<br>5.3/psi | 65.7 | 20.8 | 99%<br>96%<br>99.99% | 0.64 |

[1] Root mean square error
[2] Indicates that driveability degrades with increasing ambient temperature
[3] Indicates that driveability improves with increasing $T_{50}$
[4] Indicates that driveability degrades with increasing RVP

## TABLE 8
# TWD by RVP and Altitude for Injected Vehicles

| Altitude | Temperature ( $^{0}$F) | RVP (psi) | Significant effects | Magnitude of effect (TWD) | Mean (TWD) | RMSE[1] (TWD) | Confidence level | $r^2$ for correlation |
|---|---|---|---|---|---|---|---|---|
| high | ≤80 | 7.5 | $T_{50}$ | -4.0/20°F[2] | 16.0 | 9.3 | 98% | 0.64 |
| high | ≥80 | 7.5 | $T_{50}$ | -2.1/20°F | 15.0 | 8.1 | 93% | 0.75 |
| low | ≥90 | 7.5 | none | | 29.0 | 11.7 | | 0.84 |
| high | ≤80 | 11.5 | Temperature | 7.5/10°F[3] | 14.0 | 7.7 | 99% | 0.68 |
| high | ≥80 | 11.5 | none | | 17.8 | 14.8 | | 0.69 |

[1] Root mean square error
[2] Indicates that driveability improves with increasing $T_{50}$
[3] Indicates that driveability degrades with increasing ambient temperature

## TABLE 9
# Occurrence of Major Malfunctions by RVP and Altitude for Injected Vehicles

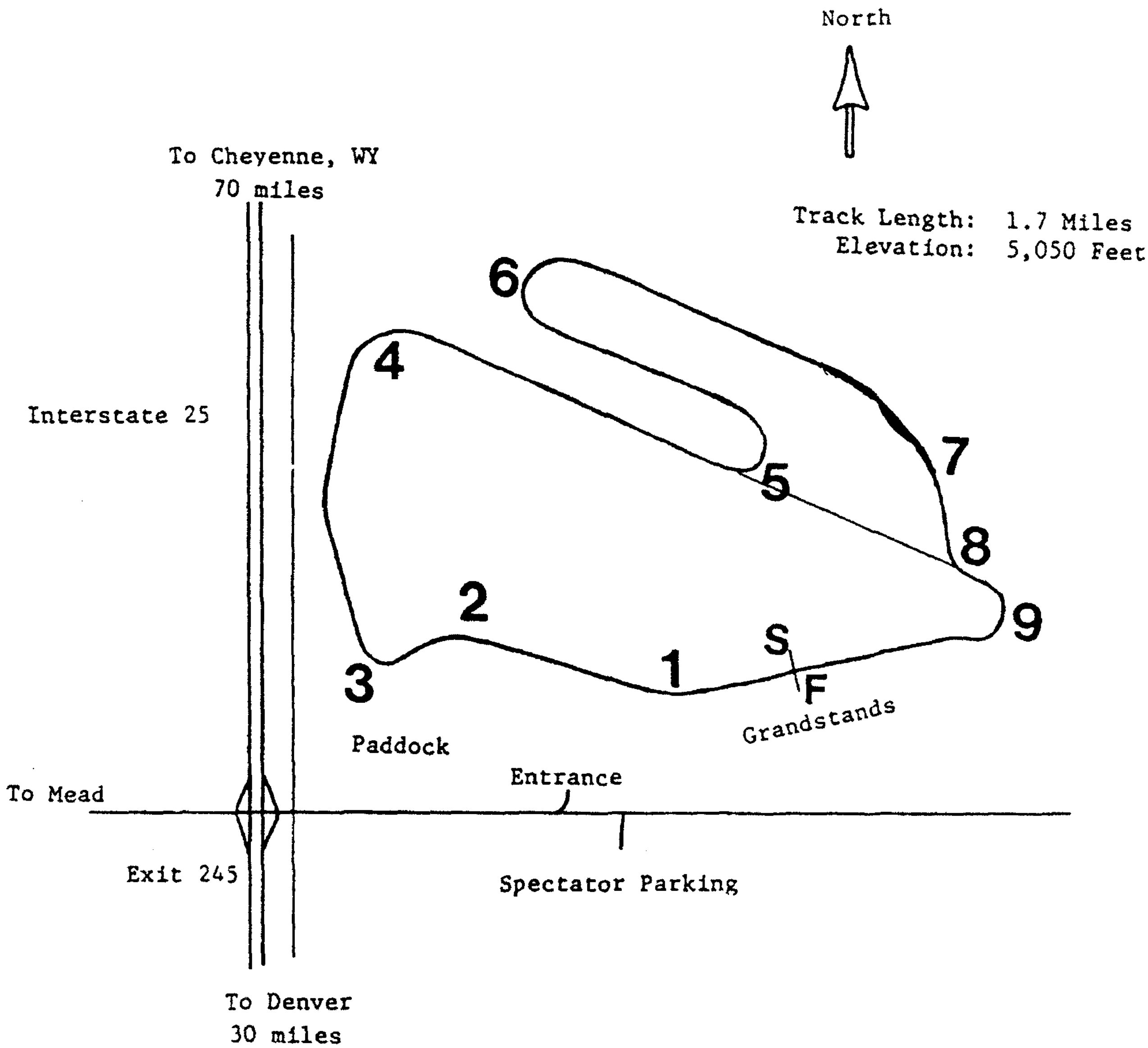
| Altitude | Temperature ( $^{0}$F) | RVP (psi) | Significant effects | Magnitude of effect (TWD) | Mean (TWD) | RMSE[1] (TWD) | Confidence level | $r^2$ for correlation |
|---|---|---|---|---|---|---|---|---|
| high | ≤80 | 7.5 | none | | 0.09 | 0.55 | | 0.10 |
| high | ≥80 | 7.5 | Temperature | 0.34/10°F[2] | 0.076 | 0.34 | 97% | 0.25 |
| low | ≥90 | 7.5 | none | | 0.70 | 0.74 | | 0.78 |
| high | ≤80 | 11.5 | Temperature | 0.36/10°F | 0.10 | 0.46 | 98% | 0.26 |
| high | ≥80 | 11.5 | none | | 0.41 | 0.77 | | 0.63 |

[1] Root mean square error
[2] Indicates that driveability degrades with increasing ambient temperature

Mountain View Motor Sport Park



**Figure 1**




4133 Weld County Road 34, P.O. Box 687
Mead, Colorado 80542-0687 Telephone (303) 535-4907

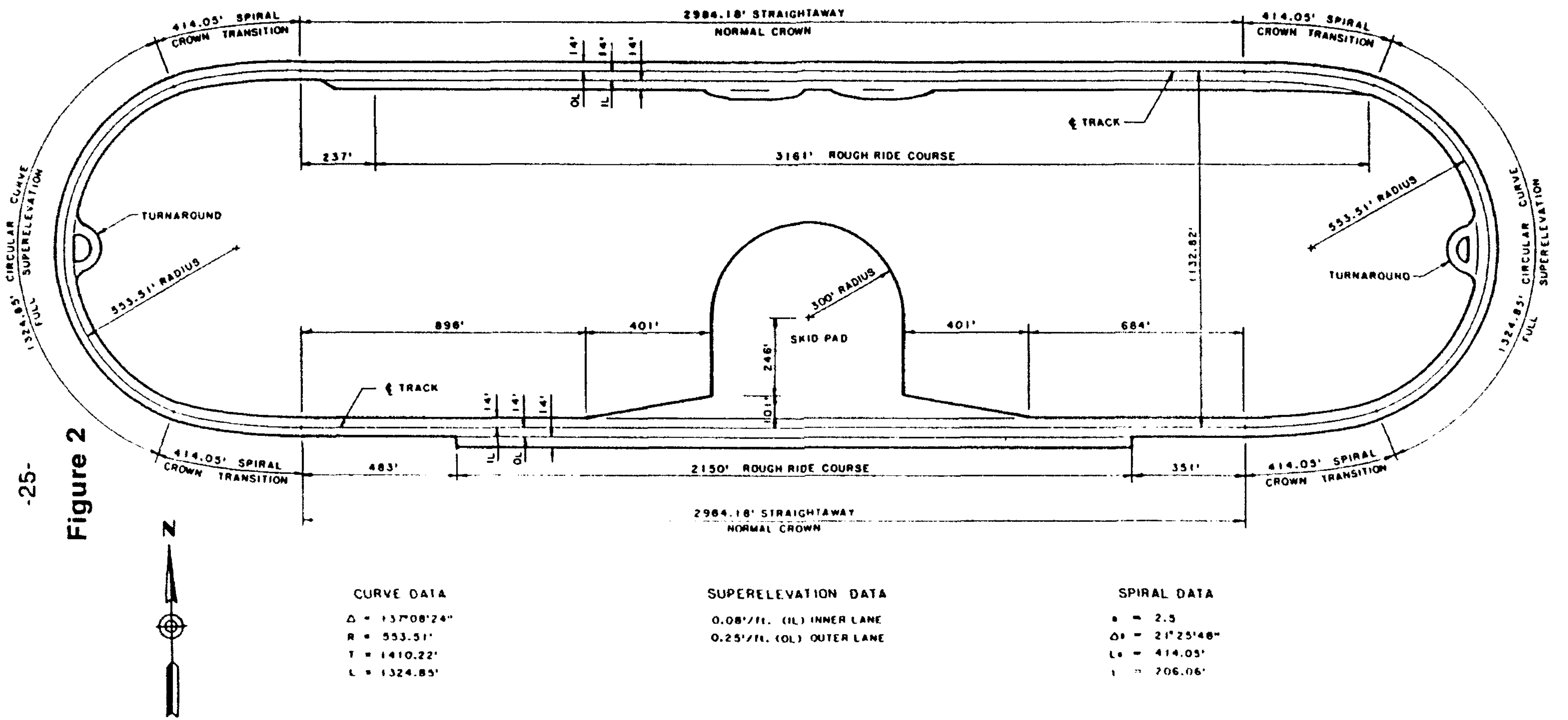



Figure 2

CURVE DATA

Δ = 137°08'24"
R = 553.51'
T = 1410.22'
L = 1324.85'

SUPERELEVATION DATA

0.08'/ft. (IL) INNER LANE
0.25'/ft. (OL) OUTER LANE

SPIRAL DATA

a = 2.5
Δs = 21°25'48"
Ls = 414.05'
t = 706.06'

LENGTH OF TRACK
10274.26 FEET
1.9459 MILES

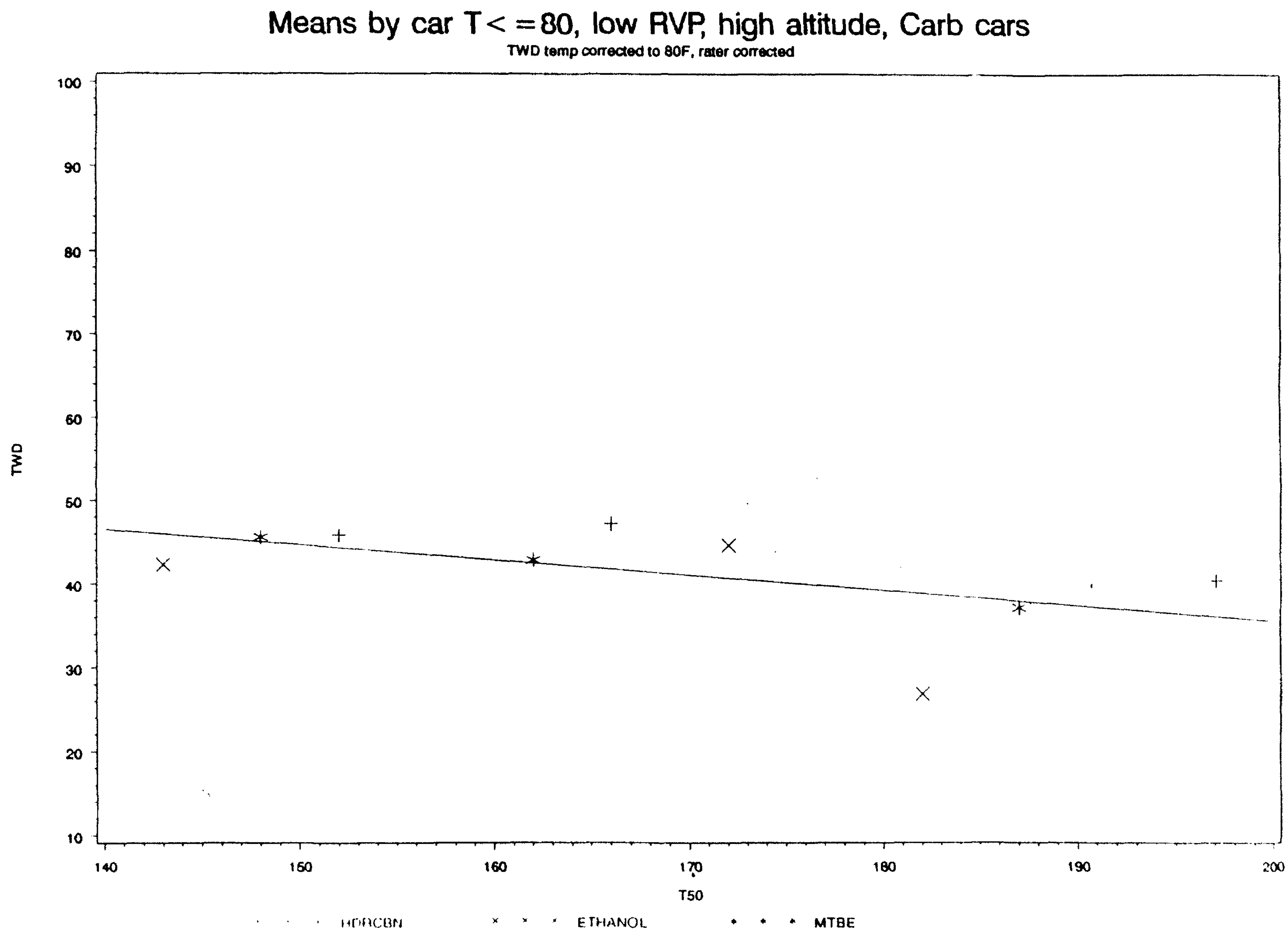

Means by car T< =80, low RVP, high altitude, Carb cars
TWD temp corrected to 80F, rater corrected
TWD
100
90
80
70
60
50
40
30
20
10
140
150
160
170
180
190
200
T50
HDRCBN
ETHANOL
MTBE

Figure 3

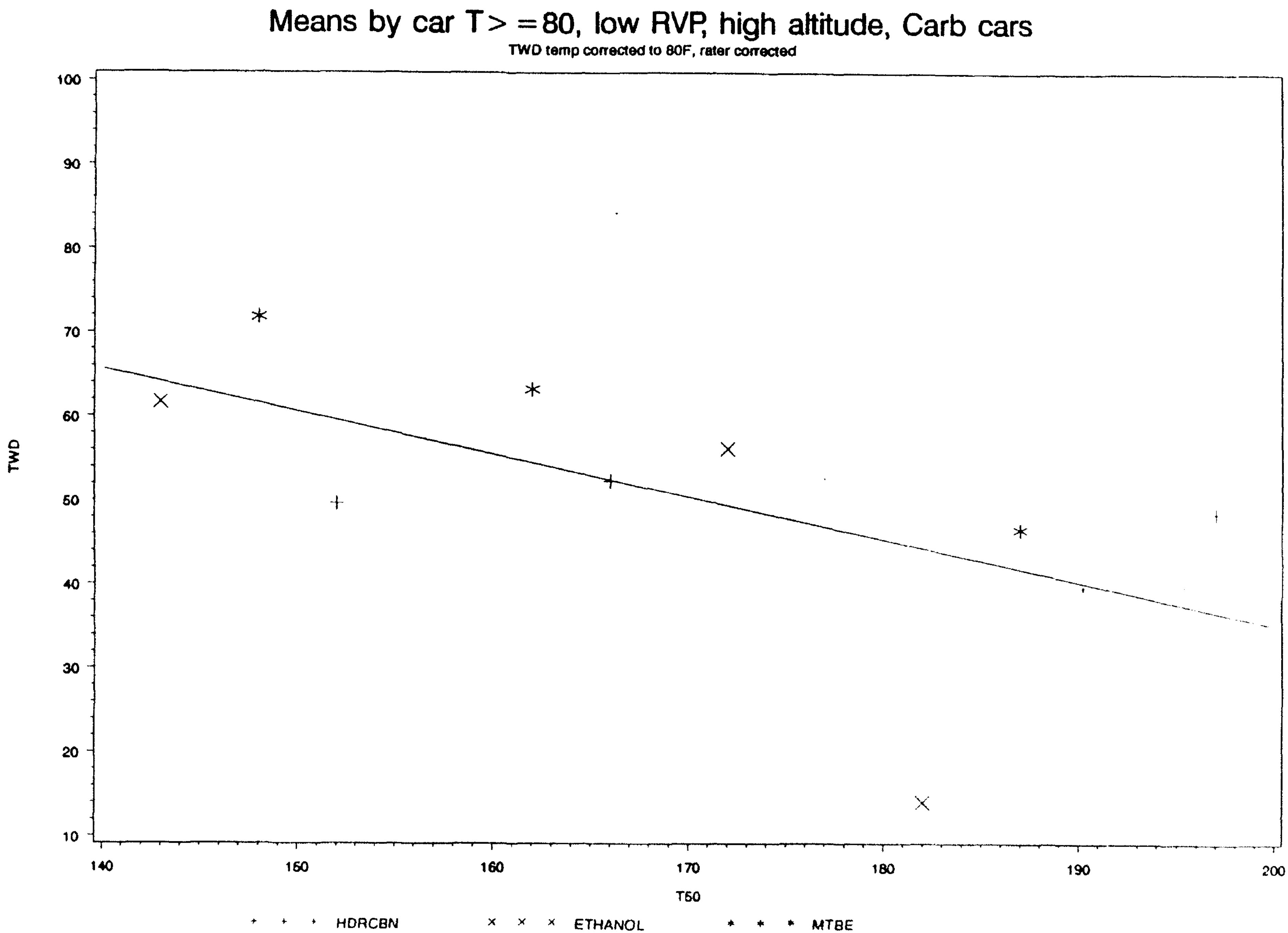

Means by car T> =80, low RVP, high altitude, Carb cars
TWD temp corrected to 80F, rater corrected
TWD
100
90
80
70
60
50
40
30
20
10
140
150
160
170
180
190
200
T50
HDRCBN
ETHANOL
MTBE

Figure 4

Means by car T> =90, low RVP, low altitude, Carb cars

TWD temp corrected to 90F

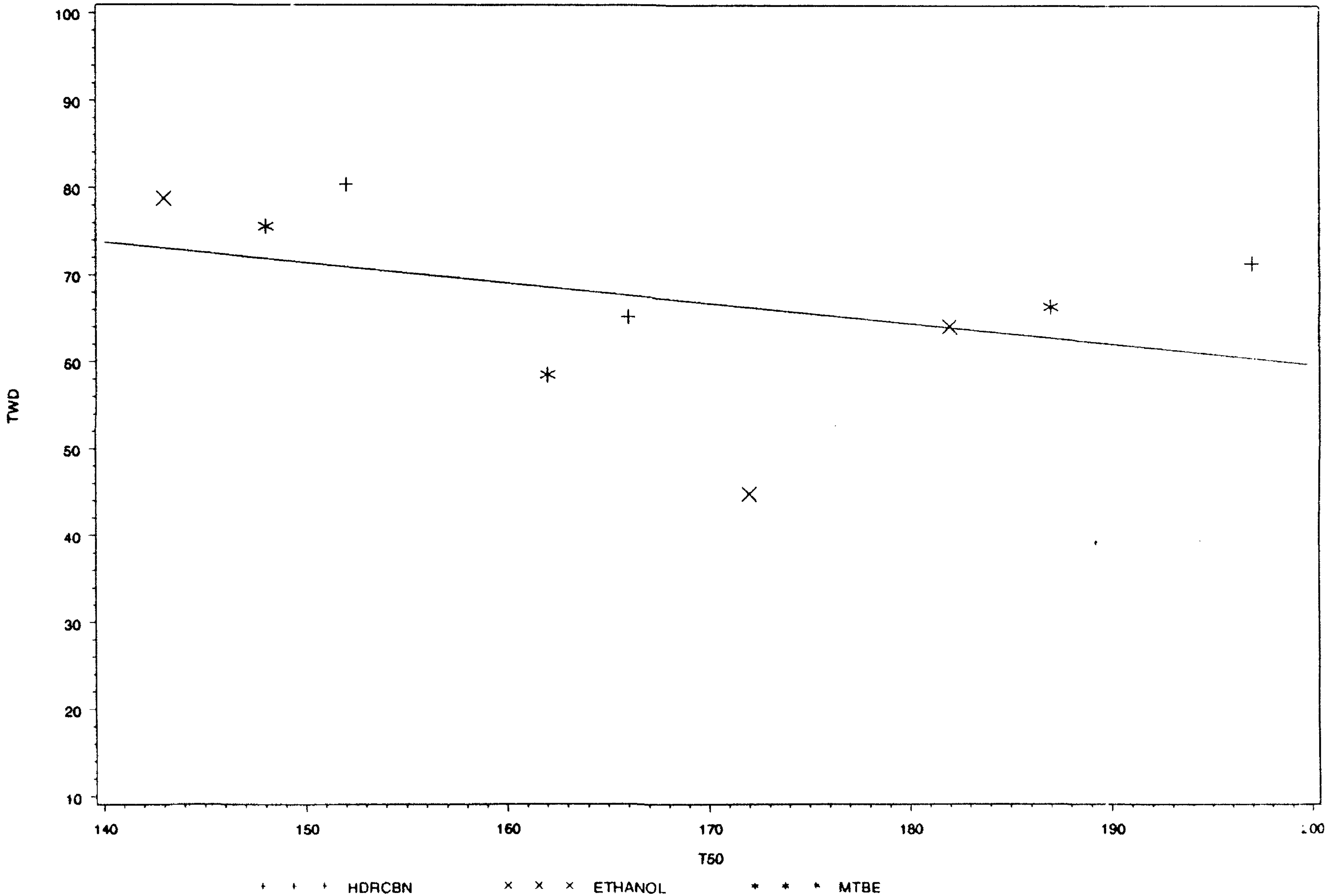
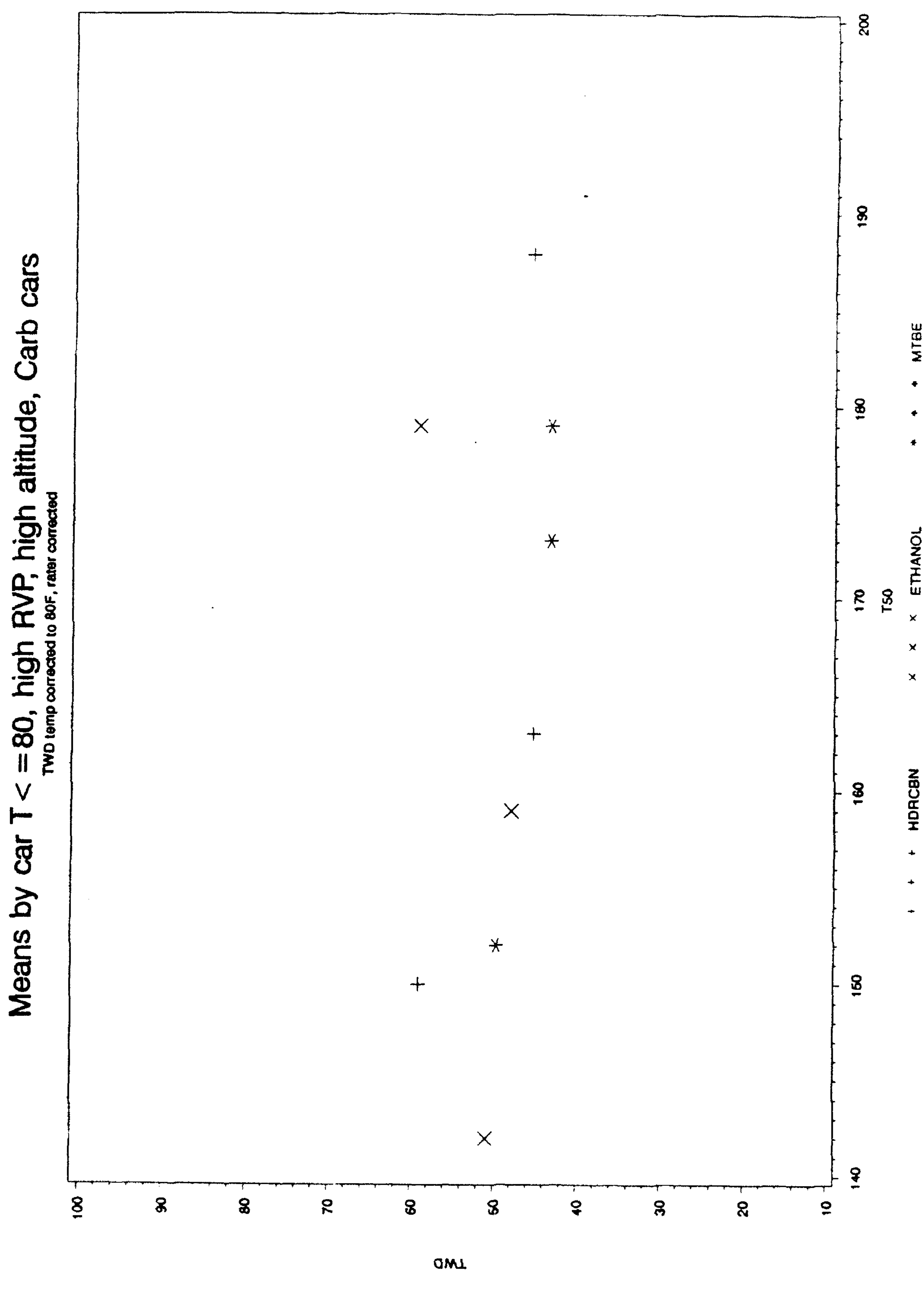
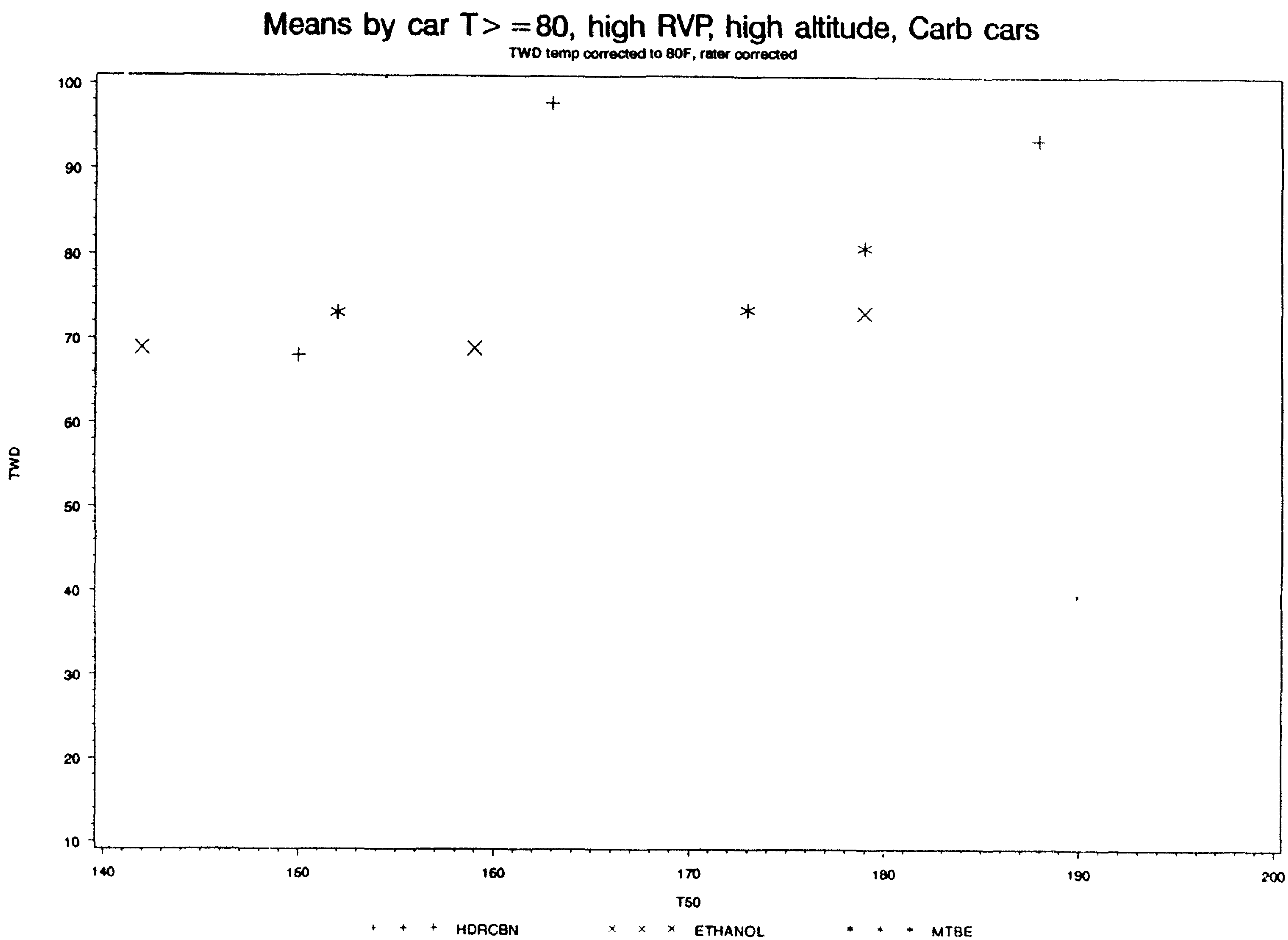



Figure 5



Means by car T<=80, high RVP, high altitude, Carb cars
TWD temp corrected to 80F, rater corrected
TWD
100
90
80
70
60
50
40
30
20
10
140
150
160
170
180
190
200
T50
HDRCBN
ETHANOL
MTBE


Figure 6



Means by car T> =80, high RVP, high altitude, Carb cars
TWD temp corrected to 80F, rater corrected
TWD
100
90
80
70
60
50
40
30
20
10
140
150
160
170
180
190
200
T50
HDRCBN
ETHANOL
MTBE


Figure 7

Means by car Fuel Injected cars

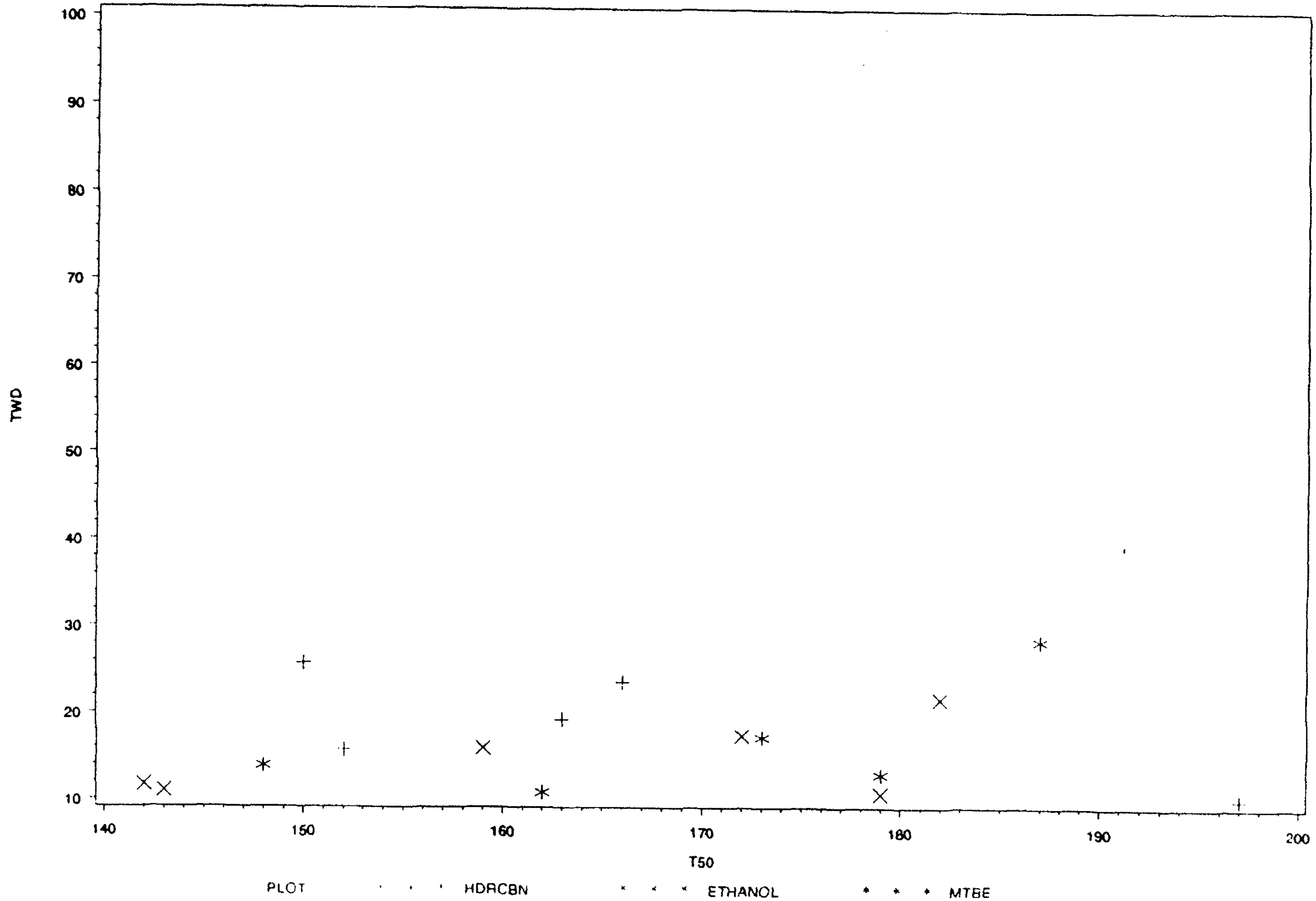



Figure 8

# APPENDIX A

# MEMBERSHIP

# OF THE

# 1992 CRC DRIVEABILITY ANALYSIS PANEL

## MEMBERSHIP OF THE

## 1992 CRC DRIVEABILITY ANALYSIS PANEL

| NAME | AFFILIATION |
|---|---|
| S.W. Jorgensen, Leader | General Motors Research Laboratories |
| C.J. Bones | Mobil Research & Development Corporation |
| D.J. Brooks | Chrysler Motors Corporation |
| J.P. Graham | Chevron Research & Technology Company |
| T.J. Karmilovich | Exxon Research & Engineering Company |
| R.M. Reuter | Texaco Inc. |
| J.H. Steury | Amoco Oil Company |

# APPENDIX B

# PARTICIPANTS IN THE

# 1992 CRC DRIVEABILITY PROGRAM

## PARTICIPANTS IN THE 1992 CRC INTERMEDIATE-TEMPERATURE DRIVEABILITY PROGRAM

| NAME | AFFILIATION |
|---|---|
| John Graham, Leader | Chevron Research & Technology Company |
| Dave Barker | Shell Development Company |
| Carl Bones | Mobil Research & Development Corporation |
| Dave Brooks | Chrysler Motors Corporation |
| Andy Buczynsky | Sun Refining & Marketing Company |
| Craig Carlson | Ford Motor Company |
| Chris Colucci | Non-Affiliated |
| Keith Corkwell | Texaco, Inc. |
| Jimmie Douglass | Shell Development Company |
| Beth Evans | Coordinating Research Council |
| Randy Feucht | Chrysler Motors Company |
| Ted Furlipa | Ford Motor Company |
| Pete Grutsch | Amoco Oil Company |
| Trude Helfrich | Toyota Technical Center |
| Scott Jorgensen | General Motors Research Laboratories |
| Ted Karmilovich | Exxon Research & Engineering Company |
| Vance McCabe | General Motors Research Laboratories |
| Doug Rathe | Shell Development Company |
| Bryan Rees | Chrysler Motors Corporation |
| Jim Robinson | Non-Affiliated |
| Bill Rozman | BP Oil Company |
| Cathy Shashok | Mobil Oil Company |
| Charlie Sherwood | Ford Motor Company |
| Steve Simms | Amoco Oil Company |
| Jim Smith | Unocal |
| Stan Stanecki | Ford Motor Company |
| Lieu Steinke | Non-Affiliated |
| Al Talbot | Sun Refining & Marketing Company |

# APPENDIX C

## 1992 CRC VOLATILITY PROGRAM TO INVESTIGATE THE EFFECTS OF RVP, $T_{50}$, AND OXYGENATES ON HOT-START AND DRIVEABILITY PERFORMANCE AT HIGH AND LOW ALTITUDE

# 1992 CRC VOLATILITY PROGRAM TO INVESTIGATE THE EFFECTS OF RVP, $T_{50}$, AND OXYGENATES ON HOT-START AND DRIVEABILITY PERFORMANCE AT HIGH AND LOW ALTITUDE

## Objective

The objective of this program is to investigate the effects of RVP, 50 percent distillation temperature ($T_{50}$), and oxygenates on hot-start and driveability performance of current-model vehicles operated at high and low altitude in the 75°F to 95°F ambient temperature range, and the 65°F to 75°F ambient temperature range.

## Background

The use of oxygenates in gasoline has become widespread during the past decade, and is expected to increase further as fuels are reformulated to reduce vehicle emissions. When either ethanol or methyl tertiary-butyl ether (MTBE) is added to gasoline, the $T_{50}$ as measured by ASTM Test Method D 86 is reduced significantly. In some cases, the $T_{50}$ drops below the minimum limit of 170°F specified in ASTM D 4814, "Standard Specification for Automotive Spark-Ignition Engine Fuel."

ASTM Subcommittee D02.A on Gasoline has been asked to review the minimum $T_{50}$ limit in D 4814 and determine whether a lower limit might be appropriate. To do this, D02.A has requested the CRC Volatility Group to conduct a hot-start and driveability test program to address this issue.

Since concern has been expressed regarding performance at low altitudes, the program has been designed to evaluate performance at both high and low altitudes during a single program using the same fuels and same vehicles.

## Test Site

The program will be conducted in two locations. The high-altitude phase of the program will be conducted at Mountain View Motor Sport Park in Longmont, Colorado, 35 miles north of Denver, at an altitude of 5,050 feet.

The low-altitude phase of the program will be conducted at the Failure Analysis Associates test track in Phoenix, Arizona, at an altitude of approximately 1,000 feet.

These test sites meet the criteria of a suitable test track, appropriate daily test temperatures, and low precipitation.

## Test Dates

The high-altitude phase of the test program will be conducted from July 7 through July 31, 1992. The low-altitude phase will be conducted from August 11 through September 3, 1992. During the August 1 through August 10 period, test vehicles, fuels, and equipment will be transported from the Denver site to the Phoenix site.

Test Fuels

The test fuel set will contain hydrocarbon (HC)-only fuels, 10 volume percent ethanol-gasoline blends, and 15 volume percent MTBE-gasoline blends. Each compositional group will be blended at two RVP levels, with three $T_{50}$'s at each RVP level.

Target fuels inspections are:

| | HC-only | HC base for EtOH Splash | MTBE Blend | MEMO: |
|---|---|---|---|---|
| $T_{50}$ | 150 | 170 | 150 | ± 5°F on |
| | 170 | 190 | 170 | distillation |
| | 190 | 210 | 190 | temperatures |
| RVP | 7.5 | 7.5 | 7.5 | ± 0.3 psi |
| | 12.0 | 12.0 | 12.0 | on RVP's |

$T_{90}$ Fixed at 325°F ± 10°F; once $T_{90}$ selected, ±5°F

Minimum (R+M)/2 = 90
Differences between the $T_{50}$ temperatures are to be maximized
Maximum 1 volume percent benzene
Maximum 32 volume percent aromatics
Ethanol is to be denatured using 5 volume percent unleaded gasoline (CDA 20)
Gasolines are to contain effective concentrations of oxidation and corrosion inhibitors
All fuels are to be unleaded

Test Vehicles

The test fleet will consist of twelve 1990-1992 model-year vehicles and six vehicles representative of older technology, selected in consultation with automotive industry representatives. The fleet will be balanced with equal number of carbureted, throttle-body-injected, and port-fuel-injected fuel systems. All vehicles will be equipped with automatic transmissions and air-conditioning.

Test Design

All eighteen vehicles will be tested on all eighteen fuels at each test location, using the test procedure outlined in Attachment 1. Three rating teams will each test six vehicles per day under high-temperature conditions and three tests per day under intermediate-temperature conditions. This yields a full-fractional factorial at high temperatures, and a half-fractional factorial at intermediate temperatures. The nine vehicles used in the intermediate-temperature testing will be selected randomly within a balance of fuel systems.

Manpower Requirements

A minimum of twelve participants will be required on-site at all times: three two-man rating crews, three warmup personnel, one fueler, one data entry person, and one program leader/track boss. It is recommended that rater rotation be minimized.

# 1992 CRC Hot Weather Driveability Test Instructions

## General:

Traffic direction on the track will be clockwise.
Take turns slowly; do not squeal tires in turns.
Do not exceed 60 MPH on track.
Do not pass any other cars.

A/C on at all times, normal level, fan one step less than high.

## Warm-Up Instructions:

After fueling vehicle, fill in top of data sheet. (Vehicle No., date, fuel no. etc. ). Warm-up at 60 MPH on highway.

Upon return to track vicinity, before entering track, drive at steady speeds of 5, 15, and 25 MPH for 30 sec. at each speed. Stop and make a lt. throttle acceleration from 0-25 MPH.

When entering track, stop; toot horn to alert driver-rater that you are back from warm-up. Check for traffic coming from the left. If clear turn right on track and complete a lap to the paddock area.

At paddock area, just past soak shelters, pull off track, turn off the engine, and turn the car over to the driver-observer team. If team is not there, complete another lap of the track and try again.

## Test Cycle

After the warm-up, the rater-observer team will take over operation of the car.

1. Start car (1 min. after it was shut off) Record start time (observer does timing).

   Starting Instructions: For carbureted cars, hold accelerator pedal partially open (1/4 throttle). For PFI or TBI cars do not depress throttle.

   If car fails to start in 10 seconds, turn the key off (lock position), wait 5 seconds and try again. If car does not start in 5 seconds of additional cranking, try to relieve flooded condition (WOT for carbureted cars, 3/4 - WOT for injected cars). Cranking times greater than 15 sec will be considered a no start. Record 20 in the start time column to indicate this condition. Otherwise, record total cranking time (15 sec. or less).

2. Record idle quality (T, M, H) or a dash (-) if satisfactory in neutral (5 sec).

3. Record idle quality in drive (5 sec). If car stalls during any of these steps, restart (do not time restart) and go to the next step. Record number of stalls. Do not allow the car to stall more than three times.

4. Access track; stop. Make a 0-60 MPH WOT acceleration. Observer is to time acceleration. Rate and record severity of any malfunctions (T, M, H).

5. At designated point, decelerate to a stop (mild braking). Make three short, sharp, light throttle 0-5 MPH accelerations. Record any malfunctions.

6. Idle in drive 5 sec. Rate quality.

7. Complete loop of track to soak shelters. Pull into soak shelter. Idle in drive (5 sec) and record idle quality. Shut off car for 20 min hot soak.

   If track boss waves you off when pulling into the soak shelters complete another lap of the track and try again.

8. After 20 min soak, toot horn to alert track boss. On his instruction, start car as in step 1.

9. Rate idle in park (5 sec). Shift to reverse, rate idle (5 sec).

10. Back out of shelter (light throttle) about 40 ft. Rate malfunctions noted. It may be necessary to turn wheel during this maneuver to provide easy access to track.

11. Shift to drive, rate idle.

12. Repeat steps 3-5.

13. Return car to fueling area.

# DEFINITIONS AND EXPLANATIONS

Test Run

Operation of a car throughout the prescribed sequence of operating conditions and/or maneuvers for a single test fuel.

Maneuver

A specified single vehicle operation or change of operating conditions (such as idle, acceleration, or cruise) that constitutes one segment of the driveability driving schedule.

Cruise

Operation at a prescribed constant vehicle speed with a fixed throttle position on a level road.

Wide Open Throttle (WOT) Acceleration

"Floorboard" acceleration through the gears from prescribed starting speed. Rate at which throttle is depressed is to be as fast as possible without producing tire squeal or appreciable slippage.

Part-Throttle (PT) Acceleration

An acceleration made an any defined throttle position, or consistent change in throttle position, less than WOT. Several PT accelerations are used. They are:

1. Light Throttle (Lt. Th) - All light-throttle accelerations are begun by opening the throttle to an initial manifold vacuum and maintaining constant throttle position throughout the remainder of the acceleration. The vacuum selected is one inch Hg greater than the initial power cut-in vacuum obtained from carburetor flow curves. However, if a 0-25 mph light-throttle maneuver (car warmed-up) cannot be completed in 0.1 mile, vacuum is decreased in steps of one inch Hg until the 0-25 maneuver can be completed in 0.1 mile. The selected vacuum is posted in each car.
2. Crowd - An acceleration made at a constant intake manifold vacuum. To maintain constant vacuum, the throttle-opening must be continually increased with increasing engine speed. Crowd accelerations are performed at the same vacuum prescribed for the light-throttle acceleration.

3. Detent - All detent accelerations are begun by opening the throttle to the downshift position as indicated by transmission shift characteristic curves. Manifold vacuum corresponding to this point at 25 mph is posted in each car. Constant throttle position is maintained to 35 mph in this maneuver.

## Malfunctions

1. Stall

Any occasion during a test when the engine stops with the ignition on. Three types of stall, indicated by location on the data sheet, are:

a. Stall; idle - Any stall experienced when the vehicle is not in motion, or when a maneuver is not being attempted.

b. Stall; maneuvering - Any stall which occurs during a prescribed maneuver or attempt to maneuver.

c. Stall; decelerating - Any stall which occurs while decelerating between maneuvers.

2. Idle Roughness

An evaluation of the idle quality or degree of smoothness while the engine is idling.

3. Backfire

An explosion in the induction or exhaust system.

4. Hesitation
A temporary lack of vehicle response to opening of the throttle.

5. Stumble

A short, sharp reduction in acceleration after the vehicle is in motion.

6. Surge
   Cyclic power fluctuations occurring during acceleration or cruise.

## Malfunction Severity Ratings

The number of stalls encountered during any maneuver are to be listed in the appropriate data sheet column. Each of the other malfunctions must be rated by severity and the letter designation entered on the data sheet. The following definitions of severity are to be applied in making such ratings.

1. Trace (T) - A level of malfunction severity that is just discernible to a test driver but not to most laymen.

2. Moderate (M) - A level of malfunction severity that is probably noticeable to the average laymen.

3. Heavy (H) - A level of malfunction severity that is pronounced and obvious to both test driver and layman.

Enter a T, M, or H in the appropriate data block to indicate both the occurrence of the malfunction and its severity. More than one type of malfunction may be recorded on each line. If no malfunction occur, enter a dash (-) to indicated that the maneuver was performed and operation was satisfactory during the maneuver.

# 1992 CRC Hot Weather Driveability Data Sheet

Vehicle No.________ Fuel No.________ Driver; warm-up________

Date________________ Gallons__________ Driver; test____________

Observer____________

| | Time | Odometer | Temp |
|---|---|---|---|
| Start of warm-up | ________ | __________ | ________ |
| Start of Soak | ________ | __________ | ________ |
| End of Test | ________ | __________ | ________ |

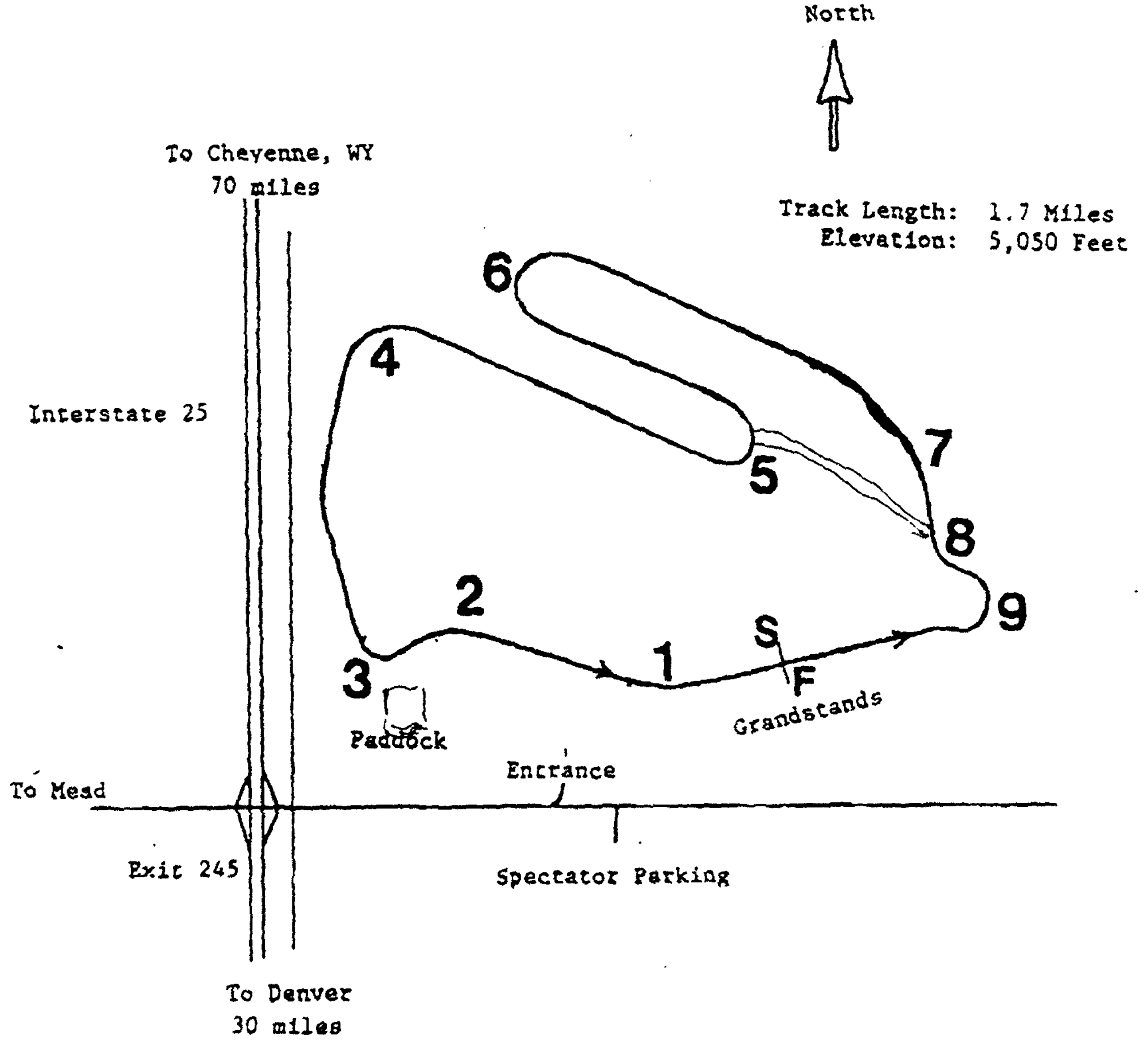
Intended Test:

High Temp ________

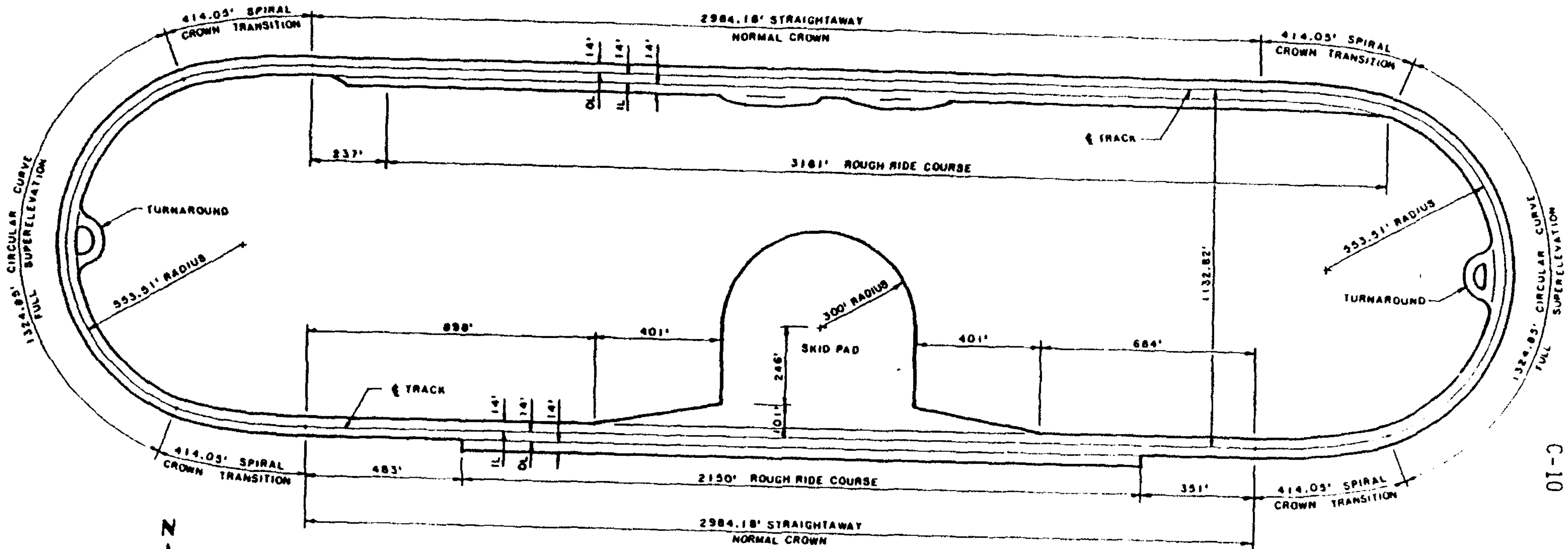
Intermediate______

| | Time Sec | | Idle | | Driving | | | | | TWD |
|---|---|---|---|---|---|---|---|---|---|---|
| Maneuver | 1st try | 2nd try | Rough | Stall | Hesit | Stum | Surge | B. Fire | Stall | |
| Base start | | | | | | | | | | |
| idle (N) | | | | | | | | | | |
| idle (D) | | | | | | | | | | |
| 0-60 WOT | | | | | | | | | | |
| 0-5 lt throt | | | | | | | | | | |
| 0-5 | | | | | | | | | | |
| 0-5 | | | | | | | | | | |
| idle (D) | | | | | | | | | | |
| shed idle (D) | | | | | | | | | | |
| Hot Start | | | | | | | | | | |
| idle (P) | | | | | | | | | | |
| idle (R) | | | | | | | | | | |
| Bk-up, lt throt | | | | | | | | | | |
| Idle (D) | | | | | | | | | | |
| 0-60 WOT | | | | | | | | | | |
| 0-5 lt th | | | | | | | | | | |
| 0-5 | | | | | | | | | | |
| 0-5 | | | | | | | | | | |
| Idle (D) | | | | | | | | | | |

Mountain View Motor Sport Park




4133 Weld County Road 34, P.O. Box 687
Mead, Colorado 80542-0687 Telephone (303) 535-4907





**CURVE DATA**

$\Delta$ = 137°08'24"
R = 553.51'
T = 1410.22'
L = 1324.85'

**SUPERELEVATION DATA**

0.08'/ft. (IL) INNER LANE
0.25'/ft. (OL) OUTER LANE

**SPIRAL DATA**

k = 2.5
$\Delta$s = 21°25'48"
Ls = 414.05'
c = 206.06'

**LENGTH OF TRACK**

10274.26 FEET
1.9459 MILES

Failure Analysis Associates
1850 Pinnacle Peak Road
Phoenix, Arizona 85027

602/582-6949

# APPENDIX D

# INDIVIDUAL LABORATORY FUEL PROPERTY DATA

CRC Volatiliy Fuels

VF 1

| | A | B | C | D | AVG | STD DEV |
|---|---|---|---|---|---|---|
| API Gravity | 68.0 | 68.2 | 67.9 | 67.8 | 68.0 | 0.2 |
| Aromatics, % | 21.7 | 18.9 | 17.9 | 19.1 | 19.4 | 1.6 |
| Olefins, % | 0.4 | 0.2 | 0.6 | 0.3 | 0.4 | 0.2 |
| Saturates, % | 77.8 | 80.9 | 81.5 | 80.6 | 80.2 | 1.6 |
| Benzene, % | - | - | <.1 | - | - | - |
| RVP, psi | *5 | 7.4 | 7.3 | 7.5 | 7.4 | 0.1 |
| IBP | 115 | 99 | 100 | 84 | 100 | 13.0 |
| T10 | 134 | 131 | 132 | - | 132 | 1.6 |
| T20 | 139 | 138 | 136 | - | 137 | 1.3 |
| T30 | 143 | 142 | 139 | 142 | 141 | 1.8 |
| T40 | 148 | 147 | 144 | 147 | 146 | 1.5 |
| T50 | 153 | 153 | 149 | 152 | 152 | 1.9 |
| T60 | 162 | 160 | 156 | 160 | 160 | 2.6 |
| T70 | 182 | 177 | 172 | 177 | 177 | 4.3 |
| T80 | *262 | 237 | 226 | 248 | 237 | 10.5 |
| T90 | 329 | 320 | 323 | 320 | 323 | 4.4 |
| EP | 409 | 412 | 388 | 420 | 407 | 14 |
| % Recovered | 97.7 | 98.0 | 98.9 | 97.9 | - | - |
| % Residue | 1.1 | 1.2 | 1.0 | 1.1 | - | - |
| % Loss | 1.2 | 0.8 | 0.1 | 1.0 | - | - |
| RON | - | - | 90.5 | - | 90.5 | - |
| MON | - | - | 86.2 | - | 86.2 | - |
| (R+M)/2 | - | - | 88.4 | - | 88.4 | - |
| MTBE, % | - | - | - | - | - | - |
| Ethanol, % | - | - | - | - | - | - |

CRC Volatiliy Fuels

VF 3

| | A | B | C | D | AVG | STD DEV |
|---|---|---|---|---|---|---|
| API Gravity | 69.9 | 70.1 | 69.8 | 70.1 | 70.0 | 0.15 |
| Aromatics, % | 15.5 | 13.2 | 12.4 | 13.3 | 13.6 | 1.3 |
| Olefins, % | 0.8 | 0.2 | 0.5 | 0.3 | 0.5 | 0.3 |
| Saturates, % | 83.7 | 86.6 | 87.1 | 86.4 | 86.0 | 1.5 |
| Benzene, % | - | 0.10 | 0.20 | 0.10 | 0.13 | 0.06 |
| RVP, psi | 7.6 | 7.6 | 7.7 | 7.2 | 7.5 | 0.2 |
| IBP | 109 | 97 | 98 | 84 | 97 | 10.0 |
| T10 | 136 | 128 | 128 | - | 131 | 4.4 |
| T20 | 143 | 138 | 137 | - | 139 | 3.0 |
| T30 | 150 | 146 | 145 | 147 | 147 | 1.9 |
| T40 | 158 | 154 | 154 | 155 | 155 | 1.8 |
| T50 | 168 | 163 | 162 | 165 | 165 | 2.4 |
| T60 | 183 | 175 | 176 | 179 | 178 | 3.5 |
| T70 | 208 | 197 | 201 | 204 | 203 | 4.9 |
| T80 | 256 | 237 | 245 | 249 | 247 | 8.0 |
| T90 | 331 | 304 | 318 | 318 | 318 | 11.4 |
| EP | 402 | 402 | 402 | 400 | 402 | 1 |
| % Recovered | 98.8 | 96.8 | 96.1 | 97.9 | - | - |
| % Residue | 1.0 | 1.1 | 1.0 | 1.0 | - | - |
| % Loss | 0.2 | 2.1 | 2.9 | 1.1 | - | - |
| RON | - | - | - | - | - | - |
| MON | - | - | - | - | - | - |
| (R+M)/2 | - | - | - | - | - | - |
| MTBE,vol% | - | - | - | - | - | - |
| Ethanol, % | - | - | - | - | - | - |

CRC Volatiliy Fuels

VF 5

| | A | B | C | D | AVG | STD DEV |
|---|---|---|---|---|---|---|
| API Gravity | 63.1 | 63.5 | - | - | 63.3 | 0.28 |
| Aromatics, % | 27.3 | 24.8 | 21.7 | 22.2 | 24.0 | 2.6 |
| Olefins, % | 0.7 | 0.2 | 0.5 | 0.0 | 0.4 | 0.3 |
| Saturates, % | 72.0 | 75.0 | 77.7 | 77.8 | 75.6 | 2.7 |
| Benzene, % | - | 0.30 | 0.30 | - | 0.30 | 0.00 |
| RVP, psi | 7.3 | 7.5 | 7.4 | 7.6 | 7.5 | 0.1 |
| IBP | 105 | 85 | 92 | 89 | 93 | 9.0 |
| T10 | 132 | 127 | 131 | - | 130 | 2.3 |
| T20 | 144 | 140 | 144 | - | 143 | 2.2 |
| T30 | 158 | 154 | 158 | 155 | 156 | 2.1 |
| T40 | 176 | 171 | 175 | 172 | 174 | 2.3 |
| T50 | 198 | 192 | 196 | 194 | 195 | 2.7 |
| T60 | 226 | 219 | 223 | 222 | 222 | 2.8 |
| T70 | 257 | 249 | 253 | 253 | 253 | 3.4 |
| T80 | 297 | 288 | 292 | 291 | 292 | 3.9 |
| T90 | 338 | 329 | 332 | 330 | 332 | 3.8 |
| EP | 418 | 376 | 412 | 419 | 406 | 20.0 |
| % Recovered | 97.1 | 97.0 | 98.9 | 97.6 | | - |
| % Residue | 1.1 | 2.3 | 1.1 | 1.0 | - | - |
| % Loss | 1.8 | 0.7 | 0.0 | 1.4 | - | - |
| RON | - | - | - | - | - | - |
| MON | - | - | - | - | - | - |
| (R+M)/2 | - | - | - | - | - | - |
| MTBE, vol% | - | - | - | - | - | - |
| Ethanol, vol% | - | - | - | - | - | - |

CRC Volatiliy Fuels

VF 7

| | A | B | C | D | AVG | STD DEV |
|---|---|---|---|---|---|---|
| API Gravity | 63.7 | 63.9 | 63.3 | 63.7 | 63.7 | 0.25 |
| Aromatics, % | 30.0 | 18.8 | 19.6 | 20.3 | 22.2 | 5.3 |
| Olefins, % | 0.9 | 0.0 | 0.7 | 1.4 | 0.8 | 0.6 |
| Saturates, % | 69.1 | 81.2 | 79.7 | 78.3 | 77.1 | 5.4 |
| Benzene, % | - | <.1 | - | - | - | - |
| RVP, psi | 7.9 | 8.0 | 7.8 | 7.9 | 7.9 | 0.1 |
| IBP | 114 | 102 | 102 | 90 | 102 | 10.0 |
| T10 | 129 | 127 | 126 | - | 127 | 1.4 |
| T20 | 132 | 130 | 130 | - | 131 | 1.0 |
| T30 | 136 | 134 | 134 | 134 | 134 | 0.9 |
| T40 | 140 | 138 | 138 | 138 | 138 | 0.9 |
| T50 | 144 | 142 | 143 | 143 | 143 | 0.7 |
| T60 | 172 | 163 | 169 | 164 | 167 | 4.1 |
| T70 | 211 | 202 | 206 | 203 | 206 | 4.2 |
| T80 | 271 | 259 | 264 | 264 | 264 | 4.6 |
| T90 | 332 | 323 | 330 | 324 | 327 | 4.6 |
| EP | 411 | *338 | 419 | 409 | 413 | 5.0 |
| % Recovered | 97.8 | 93.4 | 98.8 | 98.3 | - | - |
| % Residue | 1.3 | 5.6 | 1.2 | 1.0 | - | - |
| % Loss | 0.9 | 0.3 | 0.0 | 0.7 | - | - |
| RON | - | - | 96.9 | 97.0 | 97.0 | 0.07 |
| MON | - | - | 88.9 | 89.5 | 89.2 | 0.42 |
| (R+M)/2 | - | - | 92.9 | 93.2 | 93.0 | 0.21 |
| MTBE, % | - | - | - | - | - | - |
| Ethanol, % | 9.3 | 8.7 | 10.8 | 9.2 | 9.5 | 0.9 |

CRC Volatiliy Fuels

VF 9

| | A | B | C | AVG | STD DEV |
|---|---|---|---|---|---|
| API Gravity | 62.3 | 62.2 | 61.8 | 62.1 | 0.26 |
| Aromatics, % | 27.9 | 22.4 | 19.9 | 23.4 | 4.1 |
| Olefins, % | 1.1 | 0.2 | 1.0 | 0.8 | 0.5 |
| Saturates, % | 71.0 | 77.4 | 79.1 | 75.8 | 4.3 |
| Benzene, % | - | 0.10 | 0.20 | 0.15 | 0.07 |

| | | | | | |
|---|---|---|---|---|---|
| RVP, psi | 6.9 | 7.2 | 7.1 | 7.1 | 0.1 |
| IBP | 117 | 86 | 107 | 103 | 16.0 |
| T10 | 134 | 131 | 133 | 132 | 1.3 |
| T20 | 138 | 136 | 137 | 137 | 1.1 |
| T30 | 143 | 141 | 142 | 142 | 0.6 |
| T40 | 148 | 147 | 147 | 147 | 0.6 |
| T50 | *181 | 170 | 174 | 172 | 3.5 |
| T60 | 211 | 204 | 204 | 206 | 4.1 |
| T70 | 245 | 236 | 235 | 239 | 5.2 |
| T80 | 292 | 278 | 277 | 282 | 8.2 |
| T90 | 343 | 332 | 335 | 337 | 6.1 |
| EP | 413 | 411 | *388 | 412 | 1.0 |
| % Recovered | 98.3 | 97.8 | 99.0 | - | - |
| % Residue | 1.0 | 1.2 | 0.6 | - | - |
| % Loss | 0.7 | 1.0 | 0.2 | - | - |
| RON | - | - | 97.3 | 97.3 | - |
| MON | - | - | 89.8 | 89.8 | - |
| (R+M)/2 | - | - | 93.6 | 93.6 | - |
| MTBE, vol% | - | - | - | - | - |
| Ethanol, vol% | 8.8 | 8.6 | 8.9 | 8.8 | 0.2 |

CRC Volatiliy Fuels

VF 11

| | A | B | C | D | AVG | STD DEV |
|---|---|---|---|---|---|---|
| API Gravity | 60.4 | 60.7 | 60.3 | 60.6 | 60.5 | 0.18 |
| Aromatics, % | 30.8 | 23.8 | 21.8 | 25.2 | 25.4 | 3.9 |
| Olefins, % | 0.5 | 0.2 | 1.1 | 0.4 | 0.6 | 0.4 |
| Saturates, % | 68.7 | 86.0 | 77.1 | 74.4 | 76.6 | 7.2 |
| Benzene, % | - | 0.10 | 0.30 | 0.40 | 0.27 | 0.15 |
| RVP, psi | 7.6 | 7.7 | 7.6 | 7.8 | 7.7 | 0.1 |
| IBP | 112 | 104 | 100 | 97 | 103 | 7.0 |
| T10 | 133 | 130 | 132 | - | 132 | 1.8 |
| T20 | 139 | 136 | 138 | - | 138 | 1.5 |
| T30 | 146 | 143 | 144 | 144 | 144 | 1.3 |
| T40 | 155 | 149 | 151 | 151 | 152 | 2.4 |
| T50 | *192 | 177 | 185 | 183 | 182 | 4.0 |
| T60 | 220 | 213 | 217 | 218 | 217 | 3.1 |
| T70 | 247 | 240 | 243 | 244 | 243 | 2.9 |
| T80 | 284 | 273 | 272 | 279 | 277 | 5.5 |
| T90 | 331 | 318 | 324 | 324 | 324 | 5.1 |
| EP | 409 | 410 | 397 | 412 | 407 | 7.0 |
| % Recovered | 97.8 | 97.6 | 99.0 | 97.9 | - | - |
| % Residue | 1.1 | 1.2 | 1.0 | 1.2 | - | - |
| % Loss | 1.1 | 1.2 | 0.0 | 0.9 | - | - |
| RON | - | - | 98.9 | 98.6 | 98.8 | 0.21 |
| MON | - | - | 89.8 | - | 89.8 | - |
| (R+M)/2 | - | - | 94.4 | - | 94.4 | - |
| MTBE, vol% | - | - | - | - | - | - |
| Ethanol, vol% | 9.3 | 9.5 | 11 | 9.5 | 9.8 | 0.8 |

CRC Volatiliy Fuels

VF 13

| | A | B | C | D | AVG | STD DEV |
|---|---|---|---|---|---|---|
| API Gravity | 66.8 | 66.5 | 66.0 | 66.4 | 66.4 | 0.33 |
| Aromatics, % | 20.3 | 19.0 | 18.3 | 18.2 | 19.0 | 1.0 |
| Olefins, % | 0.6 | 0.2 | 0.8 | 0.3 | 0.5 | 0.3 |
| Saturates, % | 79.1 | 80.8 | 80.9 | 81.5 | 80.6 | 1.0 |
| Benzene, % | - | 0.10 | 0.40 | 0.20 | 0.23 | 0.15 |
| RVP, psi | 7.3 | 7.6 | 7.6 | 7.7 | 7.6 | 0.2 |
| IBP | 117 | 101 | 102 | 91 | 103 | 11.0 |
| T10 | 132 | 130 | 131 | - | 131 | 1.3 |
| T20 | 136 | 135 | 134 | - | 135 | 0.9 |
| T30 | 140 | 139 | 138 | 139 | 139 | 0.7 |
| T40 | 144 | 143 | 142 | 143 | 143 | 0.7 |
| T50 | 148 | 147 | 146 | 148 | 147 | 1.0 |
| T60 | 156 | 155 | 154 | 156 | 155 | 1.1 |
| T70 | 172 | 167 | 167 | 171 | 169 | 2.9 |
| T80 | *250 | 220 | 211 | *241 | 215 | 6.0 |
| T90 | 333 | 319 | 326 | 327 | 326 | 6.0 |
| EP | 402 | 399 | 370 | 407 | 395 | 17.0 |
| % Recovered | 97.8 | 97.7 | 98.9 | 98.0 | 98.1 | 0.5 |
| % Residue | 1.0 | 1.2 | 0.9 | 1.0 | 1.0 | 0.1 |
| % Loss | 1.2 | 1.1 | 0.2 | 1.0 | 0.9 | 0.5 |
| RON | - | - | 94.9 | 95.4 | 95.2 | 0.35 |
| MON | - | - | 88.6 | 88.9 | 88.8 | 0.21 |
| (R+M)/2 | - | - | 91.8 | 92.2 | 92.0 | 0.28 |
| MTBE, vol% | 14.1 | 14.5 | 14.5 | 14.7 | 14.5 | 0.3 |
| Ethanol, vol% | - | - | - | - | - | - |

CRC Volatiliy Fuels

VF 15

| | A | B | C | D | AVG | STD DEV |
|---|---|---|---|---|---|---|
| API Gravity | 62.1 | - | 62.1 | - | 62.1 | 0.00 |
| Aromatics, % | 31.3 | 27.3 | 24.8 | 25.3 | 27.2 | 3.0 |
| Olefins, % | 1.1 | 0.0 | 0.6 | 0.0 | 0.4 | 0.5 |
| Saturates, % | 67.6 | 72.7 | 74.6 | 74.7 | 72.4 | 3.3 |
| Benzene, % | - | 0.10 | 0.10 | - | 0.10 | 0.00 |
| RVP, psi | 7.6 | 7.7 | 7.5 | 7.6 | 7.6 | 0.1 |
| IBP | 109 | 95 | 95 | 85 | 96 | 10.0 |
| T10 | 128 | 125 | 126 | - | 126 | 1.6 |
| T20 | 134 | 133 | 133 | - | 134 | 0.7 |
| T30 | 142 | 140 | 141 | 141 | 141 | 1.1 |
| T40 | 151 | 148 | 150 | 151 | 150 | 1.3 |
| T50 | 164 | 162 | 164 | 165 | 164 | 1.2 |
| T60 | 187 | 183 | 186 | 187 | 186 | 2.2 |
| T70 | 236 | 228 | 232 | 236 | 233 | 4.0 |
| T80 | 296 | 288 | 292 | 293 | 292 | 3.6 |
| T90 | 339 | 331 | 334 | 332 | 334 | 3.3 |
| EP | 413 | 415 | 411 | 424 | 416 | 6.0 |
| % Recovered | 97.7 | 98.0 | 98.9 | 98.0 | - | - |
| % Residue | 1.2 | 1.3 | 1.1 | 1.2 | - | - |
| % Loss | 1.1 | 0.7 | 0.0 | 0.8 | - | - |
| RON | - | - | - | - | - | - |
| MON | - | - | - | - | - | - |
| (R+M)/2 | - | - | - | - | - | - |
| MTBE, % | 14.0 | 14.3 | 15.0 | 15.0 | 14.6 | 0.5 |
| Ethanol, % | - | - | - | - | - | - |

CRC Volatiliy Fuels

VF 17

| | A | C | B | D | AVG | STD DEV |
|---|---|---|---|---|---|---|
| API Gravity | 62.3 | 62.6 | 62.3 | 62.4 | 62.4 | 0.14 |
| Aromatics, % | 25.4 | 22.2 | 30.0 | 23.1 | 25.2 | 3.5 |
| Olefins, % | 0.6 | 0.2 | 0.6 | 0.5 | 0.5 | 0.2 |
| Saturates, % | 74.0 | 77.6 | 79.4 | 76.4 | 76.9 | 2.3 |
| Benzene, % | - | 0.50 | 0.50 | 0.50 | 0.50 | 0.00 |
| RVP, psi | 7.2 | 7.2 | 7.2 | 7.4 | 7.2 | 0.1 |
| IBP | 105 | 95 | 94 | 90 | 96 | 6.0 |
| T10 | 135 | 128 | 132 | - | 132 | 3.8 |
| T20 | 146 | 141 | 142 | - | 143 | 2.6 |
| T30 | 157 | 151 | 154 | 155 | 154 | 2.3 |
| T40 | 170 | 164 | 168 | 169 | 168 | 2.8 |
| T50 | 188 | 181 | 184 | 186 | 185 | 3.1 |
| T60 | 213 | 204 | 209 | 211 | 209 | 3.9 |
| T70 | 243 | 232 | 237 | 240 | 238 | 4.6 |
| T80 | 277 | 265 | 270 | 274 | 272 | 5.2 |
| T90 | 322 | 308 | 319 | 315 | 316 | 5.9 |
| EP | 396 | 392 | 388 | 393 | 392 | 3.0 |
| % Recovered | 97.9 | 97.0 | 98.6 | 97.4 | - | - |
| % Residue | 1.0 | 1.3 | 1.2 | 1.0 | - | - |
| % Loss | 1.1 | 1.7 | 0.2 | 1.6 | - | - |
| RON | - | - | 97.9 | - | 97.9 | - |
| MON | - | - | 90.1 | - | 90.1 | - |
| (R+M)/2 | - | - | 94.0 | - | 94.0 | - |
| MTBE, % | - | 14.1 | 15.2 | 15.5 | 14.9 | 0.7 |
| Ethanol, % | - | - | - | - | - | - |

CRC VOLATILTIY FUELS

VF 2

| | A | B | C | D | AVG | STD DEV |
|---|---|---|---|---|---|---|
| API Gravity | 70.7 | 71.0 | 70.5 | 70.8 | 70.8 | 0.21 |
| Aromatics, % | 20.3 | 15.8 | 15.6 | 17.3 | 17.3 | 2.2 |
| Olefins, % | 0.5 | 0.2 | 0.7 | 0.5 | 0.5 | 0.2 |
| Saturates, % | 79.2 | 84.0 | 83.7 | 82.2 | 82.3 | 2.2 |
| Benzene, % | - | - | <.1 | - | - | - |
| RVP, psi | 11.6 | 11.6 | 11.7 | 10.9 | 11.4 | 0.4 |
| IBP, F | 94 | 83 | 85 | 77 | 85 | 7 |
| T10 | 115 | 105 | 116 | - | 112 | 6.0 |
| T20 | 125 | 118 | 126 | - | 123 | 4.1 |
| T30 | 134 | 129 | 136 | 132 | 133 | 3.0 |
| T40 | 143 | 138 | 144 | 140 | 141 | 2.6 |
| T50 | 150 | 146 | 152 | 148 | 149 | 2.4 |
| T60 | 159 | 154 | 162 | 156 | 158 | 3.2 |
| T70 | 176 | 164 | 186 | 171 | 174 | 9.5 |
| T80 | 246 | *204 | 283 | 231 | 253 | 27.0 |
| T90 | 330 | *295 | 350 | 314 | 331 | 17.0 |
| EP | 411 | 404 | 418 | 408 | 410 | 6 |
| RON | - | - | 90.8 | - | 90.8 | - |
| MON | - | - | 86.7 | - | 86.7 | - |
| (R+M)/2 | - | - | 88.8 | - | 88.8 | - |
| MTBE,% | - | - | - | - | - | - |
| Ethanol, % | - | - | - | - | - | - |

CRC Volatiliy Fuels

VF 4

| | A | B | C | D | AVG | STD DEV |
|---|---|---|---|---|---|---|
| API Gravity | 72.9 | 72.7 | 72.3 | 72.2 | 72.5 | 0.33 |
| Aromatics, % | 14.0 | 11.5 | 17.9 | 9.4 | 13.2 | 3.7 |
| Olefins, % | 0.8 | 0.2 | 0.6 | 0.3 | 0.5 | 0.3 |
| Saturates, % | 85.2 | 88.3 | 81.5 | 97.5 | 88.1 | 6.8 |
| Benzene, % | - | <.1 | 0.10 | 0.10 | 0.10 | 0.00 |
| RVP, psi | 11.6 | 11.6 | 11.7 | *10.15 | 11.6 | 0.1 |
| IBP | 91 | 80 | 86 | 76 | 83 | 7.0 |
| T10 | 114 | 105 | 110 | - | 110 | 4.3 |
| T20 | 127 | 121 | 126 | - | 125 | 3.2 |
| T30 | 139 | 134 | 139 | 136 | 137 | 2.3 |
| T40 | 150 | 146 | 151 | 148 | 149 | 2.0 |
| T50 | 161 | 158 | 162 | 160 | 161 | 1.6 |
| T60 | 175 | 171 | 177 | 173 | 174 | 2.3 |
| T70 | 198 | 191 | 201 | 195 | 196 | 4.4 |
| T80 | 245 | 229 | 246 | 239 | 240 | 7.8 |
| T90 | 322 | *296 | 315 | 311 | 316 | 5.3 |
| EP | 405 | 395 | 396 | 396 | 398 | 5.0 |
| % Recovered | 97.9 | 96.8 | 94.5 | 97.5 | - | - |
| % Residue | 0.6 | 1.1 | 1.1 | 1.0 | - | - |
| % Loss | 1.5 | 2.1 | 4.4 | 1.5 | - | - |
| RON | - | - | - | - | - | - |
| MON | - | - | - | - | - | - |
| (R+M)/2 | - | - | - | - | - | - |
| MTBE,vol% | - | - | - | - | - | - |
| Ethanol, vol% | - | - | - | - | - | - |

CRC Volatiliy Fuels

VF 6

| | A | B | C | D | AVG | STD DEV |
|---|---|---|---|---|---|---|
| API Gravity | 66.4 | 66.2 | 65.4 | - | 66.0 | 0.53 |
| Aromatics, % | 25.7 | 21.1 | 19.7 | 19.1 | 21.4 | 3.0 |
| Olefins, % | 0.5 | 0.2 | 0.8 | 0.0 | 0.4 | 0.4 |
| Saturates, % | 73.8 | 78.7 | 79.5 | 80.9 | 78.2 | 3.1 |
| Benzene, % | - | 0.20 | 0.30 | - | 0.25 | 0.07 |
| RVP, psi | 11.4 | 11.5 | 11.4 | 11.2 | 11.4 | 0.1 |
| IBP | 90 | 80 | 83 | 81 | 84 | 5.0 |
| T10 | 112 | 101 | 109 | - | 107 | 5.7 |
| T20 | 125 | 116 | 123 | - | 121 | 4.5 |
| T30 | 141 | 132 | 140 | 136 | 137 | 4.0 |
| T40 | 161 | 153 | 161 | 157 | 158 | 3.9 |
| T50 | 188 | 180 | 190 | 185 | 188 | 4.6 |
| T60 | 220 | 212 | 222 | 217 | 218 | 4.5 |
| T70 | 250 | 242 | 251 | 248 | 248 | 3.9 |
| T80 | 291 | 278 | 290 | 286 | 286 | 6.0 |
| T90 | 334 | 321 | 332 | 328 | 329 | 5.9 |
| EP | 416 | 412 | 422 | 424 | 416 | 4.0 |
| % Recovered | 98.0 | 96.9 | 98.9 | 97.3 | - | - |
| % Residue | 1.1 | 1.2 | 1.1 | 1.0 | - | - |
| % Loss | 0.9 | 1.9 | 0.0 | 1.7 | - | - |
| RON | - | - | - | - | - | - |
| MON | - | - | - | - | - | - |
| (R+M)/2 | - | - | - | - | - | - |
| MTBE, vol% | - | - | - | - | - | - |
| Ethanol, vol% | - | - | - | - | - | - |

CRC Volatiliy Fuels

VF 8

| | A | B | C | D | AVG | STD DEV |
|---|---|---|---|---|---|---|
| API Gravity | 66.0 | 63.5 | 65.7 | 66.2 | 65.4 | 1.25 |
| Aromatics, % | 28.1 | 21.5 | 16.9 | 16.3 | 20.7 | 5.5 |
| Olefins, % | 1.0 | 0.0 | 0.6 | 1.4 | 0.8 | 0.6 |
| Saturates, % | 70.9 | 78.5 | 82.5 | 83.2 | 78.8 | 5.6 |
| Benzene, % | - | - | - | - | - | - |
| RVP, psi | 11.3 | 11.5 | 11.2 | 11.2 | 11.3 | 0.1 |
| IBP | 96 | 89 | 89 | 80 | 89 | 7.0 |
| T10 | 116 | 111 | 116 | - | 114 | 2.8 |
| T20 | 124 | 121 | 124 | - | 123 | 1.7 |
| T30 | 131 | 128 | 130 | 129 | 129 | 1.3 |
| T40 | 136 | 134 | 136 | 135 | 135 | 0.9 |
| T50 | 142 | 140 | 142 | 140 | 141 | 1.4 |
| T60 | 162 | 149 | 160 | 152 | 156 | 6.3 |
| T70 | 200 | 189 | 198 | 193 | 195 | 5.4 |
| T80 | 263 | 246 | 260 | 253 | 255 | 7.4 |
| T90 | 330 | 314 | 329 | 314 | 322 | 8.8 |
| EP | 409 | *344 | 416 | 413 | 413 | 4 |
| % Recovered | 97.5 | 94.5 | 98.2 | 97.3 | - | - |
| % Residue | 1.4 | 4.5 | 1.4 | 0.8 | - | - |
| % Loss | 1.1 | 1.0 | 0.4 | 1.9 | - | - |
| Ron | - | - | 96.6 | 97.0 | 96.8 | 0.28 |
| MON | - | - | 88.7 | 89.7 | 89.2 | 0.71 |
| (R+M)/2 | - | - | 92.7 | 93.4 | 92.7 | 0.49 |
| MTBE, vol% | - | - | - | - | - | - |
| Ethanol, vol% | 8.8 | 9.0 | 10.2 | 8.5 | 9.1 | 0.8 |

CRC Volatiliy Fuels

VF 10

| | A | B | C | AVG | STD DEV |
|---|---|---|---|---|---|
| API Gravity | 65.9 | 66.0 | 65.5 | 65.8 | 0.26 |
| Aromatics, % | 22.2 | 16.6 | 16.2 | 18.3 | 3.4 |
| Olefins, % | 1.1 | 0.2 | 1.0 | 0.8 | 0.5 |
| Saturates, % | 76.7 | 83.2 | 82.8 | 80.9 | 3.6 |
| Benzene, % | - | 0.10 | 0.20 | 0.15 | 0.07 |
| RVP, psi | 11.7 | 11.7 | 11.7 | 11.7 | 0.0 |
| IBP | 94 | 89 | 88 | 90 | 3.0 |
| T10 | 116 | 109 | 115 | 113 | 4.0 |
| T20 | 127 | 121 | 126 | 125 | 2.7 |
| T30 | 136 | 132 | 135 | 134 | 2.0 |
| T40 | 142 | 140 | 142 | 142 | 1.0 |
| T50 | 157 | *146 | 161 | 159 | 2.8 |
| T60 | 193 | *179 | 193 | 193 | 0.1 |
| T70 | 228 | *216 | 228 | 228 | 0.2 |
| T80 | 274 | *257 | 276 | 275 | 1.7 |
| T90 | 335 | *317 | 331 | 333 | 2.5 |
| EP | 403 | 387 | 410 | 400 | 12 |
| % Recovered | 97.6 | 96.3 | 95.5 | - | - |
| % Residue | 0.9 | 1.6 | 1.4 | - | - |
| % Loss | 1.5 | 2.1 | 3.1 | - | - |
| RON | - | - | 97.1 | 97.1 | - |
| MON | - | - | 89.9 | 89.9 | - |
| (R+M)/2 | - | - | 93.5 | 93.5 | - |
| MTBE, vol% | - | - | - | - | - |
| Ethanol, vol% | 8.1 | 8.1 | 8.3 | 8.2 | 0.1 |

CRC Volatiliy Fuels

VF 12

| | A | B | C | D | AVG | STD DEV |
|---|---|---|---|---|---|---|
| API Gravity | 63.2 | 63.4 | 63.7 | 63.2 | 63.4 | 0.24 |
| Aromatics, % | 29.9 | 21.1 | 20.7 | 21.4 | 23.3 | 4.4 |
| Olefins, % | 0.4 | 0.2 | 0.6 | 0.6 | 0.5 | 0.2 |
| Saturates, % | 69.7 | 78.7 | 78.7 | 78.0 | 76.3 | 4.4 |
| Benzene, % | - | 0.30 | 0.30 | 0.30 | 0.30 | 0.00 |
| RVP, psi | 11.6 | 11.6 | 11.5 | 11.5 | 11.6 | 0.0 |
| IBP, F | 93 | 90 | 87 | 85 | 89 | 4 |
| T10 | 118 | 108 | 116 | - | 114 | 5.1 |
| T20 | 130 | 123 | 130 | - | 128 | 4.2 |
| T30 | 140 | 135 | 141 | 138 | 139 | 3.0 |
| T40 | 148 | 144 | 149 | 146 | 147 | 2.2 |
| T50 | 176 | *156 | 181 | *166 | 179 | 3.9 |
| T60 | 213 | *197 | 216 | 206 | 212 | 4.5 |
| T70 | 242 | 231 | 244 | 238 | 238 | 5.9 |
| T80 | 278 | 263 | 284 | 273 | 274 | 9.1 |
| T90 | 328 | 310 | 332 | 320 | 322 | 9.6 |
| EP | 407 | 396 | 412 | 406 | 405 | 7 |
| % Recovered | 97.2 | 96.3 | 95.6 | 97.0 | - | - |
| % Residue | 1.2 | 1.5 | 1.8 | 1.0 | - | - |
| % Loss | 1.6 | 2.2 | 2.6 | 2.0 | - | - |
| RON | - | - | 98.2 | 98.3 | 98.2 | 0.07 |
| MON | - | - | 90.2 | - | 90.2 | - |
| (R+M)/2 | - | - | 94.2 | - | 94.2 | - |
| MTBE, % | - | - | - | - | - | - |
| Ethanol, % | - | 8.7 | 10.2 | 8.5 | 9.1 | 0.9 |

CRC Volatiliy Fuels

VF 14

| | A | B | C | D | AVG | STD DEV |
|---|---|---|---|---|---|---|
| API Gravity | 66.3 | 66.2 | 66.1 | 66.4 | 66.3 | 0.13 |
| Aromatics, % | 27.7 | 25.0 | 19.7 | 20.0 | 23.1 | 3.9 |
| Olefins, % | 0.5 | 0.2 | 0.7 | 1.4 | 0.7 | 0.5 |
| Saturates, % | 71.8 | 74.8 | 79.1 | 78.6 | 76.1 | 3.4 |
| Benzene, % | - | 0.20 | 0.10 | N.D. | 0.15 | 0.07 |
| RVP, psi | 12.0 | 12.1 | 12.0 | 11.3 | 11.8 | 0.4 |
| IBP | 88 | 81 | 84 | 78 | 83 | 4.0 |
| T10 | 108 | 106 | 111 | - | 108 | 2.5 |
| T20 | 118 | 118 | 121 | - | 119 | 1.8 |
| T30 | 127 | 127 | 131 | 126 | 128 | 2.3 |
| T40 | 136 | 138 | 142 | 136 | 138 | 2.7 |
| T50 | 149 | 150 | 156 | 149 | 151 | 3.4 |
| T60 | 167 | 168 | 178 | 167 | 167 | 0.5 |
| T70 | 204 | 203 | 225 | 202 | 203 | 1.3 |
| T80 | 274 | 276 | 296 | 271 | 273 | 2.4 |
| T90 | 330 | 326 | 342 | 322 | 326 | 4.4 |
| EP | 412 | 415 | 419 | 419 | 416 | 3.0 |
| % Recovered | 97.1 | 97.5 | 96.5 | 97.4 | - | - |
| % Residue | 1.1 | 1.2 | 1.1 | 1.0 | - | - |
| % Loss | 1.8 | 1.3 | 0.0 | 1.6 | - | - |
| RON | - | - | 98.1 | 98.3 | 98.2 | 0.14 |
| MON | - | - | 90.0 | 91.0 | 90.5 | 0.71 |
| (R+M)/2 | - | - | 94.1 | 94.6 | 94.4 | 0.35 |
| MTBE, vol% | 13.6 | 9.8 | 14.5 | 14.0 | 13.0 | 2.2 |
| Ethanol, vol% | - | - | | - | - | - |

CRC Volatiliy Fuels

VF 16

| | A | B | C | D | AVG | STD DEV |
|---|---|---|---|---|---|---|
| API Gravity | 63.3 | 63.8 | 63.3 | 63.7 | 63.5 | 0.26 |
| Aromatics, % | 29.1 | 24.8 | 24.4 | 24.2 | 25.6 | 2.3 |
| Olefins, % | 0.5 | 0.2 | 0.9 | 0.3 | 0.5 | 0.3 |
| Saturates, % | 70.4 | 75.0 | 74.7 | 75.5 | 73.9 | 2.4 |
| Benzene, % | - | 0.30 | 0.20 | 0.40 | 0.30 | 0.10 |
| RVP, psi | 11.6 | 11.7 | 11.7 | 11.6 | 11.6 | 0.0 |
| IBP | 88 | 84 | 82 | 74 | 82 | 6.0 |
| T10 | 111 | 103 | 108 | - | 107 | 4.3 |
| T20 | 123 | 117 | 122 | - | 121 | 2.9 |
| T30 | 137 | 130 | 135 | 133 | 134 | 2.7 |
| T40 | 153 | 145 | 151 | 149 | 150 | 3.5 |
| T50 | 174 | 165 | 172 | 169 | 170 | 4.0 |
| T60 | 204 | 191 | 200 | 197 | 198 | 5.6 |
| T70 | 244 | 228 | 239 | 237 | 237 | 6.5 |
| T80 | 290 | 273 | 289 | 284 | 284 | 7.7 |
| T90 | 338 | 326 | 335 | 330 | 332 | 5.6 |
| EP | 408 | 405 | 410 | 406 | 407 | 2.0 |
| % Recovered | 98.0 | 96.7 | 97.0 | 97.5 | - | - |
| % Residue | 1.0 | 1.1 | 1.1 | 1.0 | - | - |
| % Loss | 1.0 | 1.2 | 1.9 | 1.5 | - | - |
| RON | | - | 99.4 | 99.5 | 99.5 | 0.07 |
| MON | - | - | 91.2 | 91.2 | 91.2 | 0.00 |
| (R+M)/2 | - | - | 95.3 | 95.3 | 95.3 | 0.00 |
| MTBE, % | 14.8 | 14.4 | 15.8 | 14.9 | 15.0 | 0.6 |
| Ethanol, % | - | - | - | - | - | - |

CRC Volatiliy Fuels

VF 18

| | A | B | C | D | AVG | STD DEV |
|---|---|---|---|---|---|---|
| API Gravity | 65.5 | 62.6 | 65.1 | 65.6 | 64.7 | 1.42 |
| Aromatics, % | 22.6 | 21.1 | 18.8 | 18.8 | 20.3 | 1.9 |
| Olefins, % | 0.7 | 0.2 | 1.0 | 0.4 | 0.6 | 0.4 |
| Saturates, % | 76.7 | 78.7 | 80.2 | 80.8 | 79.1 | 1.8 |
| Benzene, % | - | 0.40 | 0.60 | 0.50 | 0.50 | 0.10 |
| RVP, psi | *4.1 | 11.5 | 11.5 | 11.3 | 11.4 | 0.1 |
| IBP, F | 90 | 85 | 81 | 86 | 86 | 4 |
| T10 | 114 | 103 | 110 | - | 109 | 5.7 |
| T20 | 130 | 121 | 124 | - | 125 | 4.5 |
| T30 | 145 | 137 | 140 | 142 | 141 | 3.5 |
| T40 | 163 | 154 | 156 | 159 | 158 | 3.9 |
| T50 | 181 | 172 | 174 | 178 | 176 | 4.1 |
| T60 | 206 | 194 | 198 | 202 | 200 | 5.2 |
| T70 | 237 | 223 | 228 | 233 | 230 | 5.9 |
| T80 | 274 | 256 | 260 | 269 | 265 | 8.4 |
| T90 | 321 | 300 | 313 | 313 | 312 | 8.6 |
| EP | 411 | 390 | 375 | 405 | 395 | 16 |
| % Recovered | 96.3 | 96.3 | 98.9 | 97.0 | - | - |
| % Residue | 0.8 | 1.2 | 1.1 | 0.8 | - | - |
| % Loss | 2.9 | 2.5 | 0.0 | 2.2 | - | - |
| RON | - | - | 97.4 | - | 97.4 | - |
| MON | - | - | 90.7 | - | 90.7 | - |
| (R+M)/2 | - | - | 94.1 | - | 94.1 | - |
| MTBE, % | - | 13.2 | 14.1 | 13.7 | 13.7 | 0.5 |
| Ethanol, % | - | - | - | - | - | - |

# APPENDIX E

## SPECIFIC TEST INSTRUCTIONS FOR HIGH-ALTITUDE PHASE OF

## 1992 CRC DRIVEABILITY PROGRAM

## (Mountain View Motor Sports Park, Longmont, Colorado)

Attachment I

Denver

1992 CRC Hot Weather Driveability Test Instructions

## General:

Traffic direction on the track will be clockwise.
Take turns at 30 MPH maximum; do not squeal tires in turns.
Do not exceed 60 MPH on the track.
Do not pass any other cars.

A/C on at all times, normal level, fan one step less than high.

## Warm-Up Instructions:

After fueling vehicle, fill in top of data sheet. (Vehicle No., date, fuel no., etc.). Warm-up at 65 MPH on highway.

As soon as safely possible on frontage road, drive at steady speeds of 5, 15, 25, and 35 MPH for 30 sec. at each speed. Come to a full stop at all stop signs and obey all speed limits at all times. Make light-throttle accelerations from stops.

When entering Paddock at clubhouse, stop! If rating team is not available to take-and-rate the vehicle, idle for one minute. Then take vehicle to the track. Check for traffic coming from the right. If clear, turn left on track and complete a lap to the Paddock area and return to the clubhouse.

When driver/observer team becomes available, turn off the engine, and turn the car over to the driver/observer team.

## Test Cycle:

After the warm-up, the rater/observer team will take over operation of the car.

1. Wait one minute after shut-off and start the car. Record start time (observer does timing).

   ### Starting Instructions:

   For carbureted cars, hold accelerator pedal partially open (1/4 throttle). For PFI or TBI cars do not depress throttle.

   If car fails to start in 10 seconds, turn the key off (lock position), wait 5 seconds and try again. If car does not start in 5 seconds of additional cranking, try to relieve flooded condition (WOT for carbureted cars, 3/4 - WOT for injected cars). Cranking times greater than 15 sec. will be considered a no-start.Otherwise, record total cranking time (10 sec. or less).

2. Record idle quality (T, M, H) or a dash (-) if satisfactory in neutral (utilize a full 5 seconds).

3. Record idle quality in drive (5 sec). If car stalls during any of these steps, restart (do not time restart) and go to the next step. Record number of stalls. Do not allow the car to stall more than three times.

4. Access track and drive to soak shed. Stop car so that it is aligned as much as possible with the straightaway. Make a WOT acceleration to the indicated speed for the vehicle. Observer is to time the acceleration. Rate and record severity of any malfunctions (T, M, H).

5. At designated point, decelerate to a stop (mild braking). Make three short, sharp, light throttle 0-5 MPH accelerations. Record any malfunctions.

6. Idle in drive 5 sec. Rate quality.

7. Complete loop of track to soak shelters. Pull into soak shelter. Idle in drive (5 sec) and record idle quality. Shut off car for 20 minute hot soak.

   If track boss waves you off when pulling into the soak shelters, complete another lap of the track and try again.

8. After 20 minute soak, alert the track boss. On his instruction, start car as in step 1.

9. Rate idle in park (5 sec). Shift to reverse, rate idle (5 sec).

10. Back out of shelter (light throttle) onto track. Rate malfunctions noted. It will be necessary to turn wheel during this maneuver to provide easy access to track.

11. Shift to drive, rate idle.

12. Repeat steps 3-5.

13. Return car to fueling area.

# APPENDIX F

## SPECIFIC TEST INSTRUCTIONS FOR LOW-ALTITUDE PHASE OF

## 1992 CRC DRIVEABILITY PROGRAM

## (Failure Analysis Associates, Phoenix, Arizona)

General:

Traffic direction on the track will be clockwise.

Take turns at 30 MPH maximum; do not squeal tires in turns.
Do not exceed 60 MPH on the track.
Do not pass any other cars.

A/C on at all times, normal level, fan one step less than high.

Warm-Up Instructions:

After fueling vehicle, fill in top of data sheet. (Vehicle No., date, fuel no., etc). Warm-up at 65 MPH on highway #17.

The following driving sequence is to be used during the Warm-Up.

Make light-throttle accelerations from all stops.

1. After fueling vehicle, drive the vehicle to the facility exit. Complete a steady-state conditioning mode of 5 MPH for 30 seconds while exiting the facility over the dirt-road-surface portion. Proceed to exit of facility at a safe speed.

2. At exit of facility, proceed to the access road to Route #17. Make a full-stop at the stop-sign.

3. Complete a steady-state conditioning mode of 35 MPH for 30 seconds on the access road leading to Route #17.

4. Proceed north onto Route #17 and maintain a speed of 65 MPH.

5. Exit Route #17 at Exit #223 and proceed to the southbound entrance for Route #17. Make a full-stop at stop sign.

6. Proceed onto Route #17 south and maintain a speed of 65 MPH.

7. Exit Route #17 at Exit #217 (Pinnacle Peak Road) and return to the track.

8. While returning to the Track, complete a steady-state conditioning mode of 25 MPH for 30 seconds. Use the road's dirt shoulder for this mode.

9. Proceed to the entrance of the facility. Make a full-stop at the stop sign.

10. Proceed into the facility at a safe speed. Once past the Main building and parking areas, complete a steady-state conditioning mode of 15 MPH for 30 seconds (on asphalt surface proceeding to the Track entrance). Proceed over the dirt surface area to the clubhouse at a slow speed.

When entering clubhouse area, stop! If rating team is not available to take-and-rate the vehicle, idle for one minute. Then take vehicle to the track. Check for traffic coming from the right. If clear, turn right on track and complete a lap and return to the clubhouse area.

When driver/observer team becomes available, turn off the engine, and turn the car over to the driver/observer team.

Test Cycle:

After the warm-up, the rater/observer team will take over operation of the car.

1. Wait one minute after shut-off and start the car. Record start time (observer does timing).

Starting Instructions:

For carbureted cars, hold accelerator pedal partially open (1/4 throttle). For PFI and TBI cars do not depress throttle.

If car fails to start in 10 seconds, turn the key off (lock position), wait 5 seconds and try again. If car does not start in 5 seconds of additional cranking, try to relieve flooded condition (WOT for carbureted cars, 3/4 - WOT for injected cars). Cranking times greater than 15 seconds will be considered a no-start. Otherwise, record total cranking time (10 seconds or less).

2. Record idle quality (T, M, H) or a dash (-) if satisfactory in neutral (utilize a full 5 seconds).

3. Record idle quality in drive (5 seconds). If car stalls during any of these steps, restart (do not time restart) and go to the next step. Record

number of stalls. Do not allow the car to stall more than three times.

4. Access track and drive to soak shed. Stop car so that it is aligned as much as possible with the straightaway. Make a WOT acceleration to the indicated speed for the vehicle. Observer is to time the acceleration. Rate and record severity of any malfunctions (T, M. H).

5. At designated point, decelerate to a stop (mild braking). Make three short, sharp, light throttle 0-5 MPH accelerations. Record any malfunctions.

6. Idle in drive 5 seconds. Rate quality.

7. Complete loop of track to soak shelters. Pull into soak shelter. Idle in drive (5 seconds) and record idle quality. Shut off car for 20 minute hot soak.

8. After 20 minute soak, check for traffic, when clear and safe, start car as in step 1.

9. Rate idle in park (5 seconds). Shift to reverse, rate idle (5 seconds).

10. Back out of shelter (light throttle) onto track. Rate malfunctions noted. It will be necessary to turn wheel during this maneuver to provide easy access to track.

11. Shift to drive, rate idle.

12. Repeat steps 3-5.

13. Return car to fueling area.

# APPENDIX G

## ALTERNATE TEST PROCEDURE USED DURING 1992 CRC DRIVEABILITY PROGRAM

# Alternate 1992 CRC Hot Weather Driveability Test Instructions

General:

Traffic direction on the track will be clockwise.
Take turns slowly; do not squeal tires in turns.
Do not exceed 60 MPH on the track.
Do not pass any other cars.

A/C on at all times, normal level, fan one step less than high.

Warm-Up Instructions:

After fueling vehicle, fill in top of data sheet. (Vehicle No., date, fuel no., etc). Warm-up at 60 MPH on highway.

Upon return to track vicinity, before entering track, drive at steady speeds of 5, 15, and 25 MPH for 30 seconds on each speed. Stop and make a light-throttle acceleration from 0-25 MPH.

When entering track, stop; toot horn to alert driver-rater that you are back from warm-up. Check for traffic coming from the left. If clear, turn right on track and complete a lap to the paddock area.

At paddock area, just past soak shelters, pull off track, turn off the engine, and turn the car over to the driver-observer team. If team is not there, complete another lap of the track and try again.

Test Cycle

After the warm-up, the rater-observer team will take over operation of the car.

1.Start car (1 min. after it was shut off); Record start time (observer does timing).

Starting Instructions: For carbureted cars, hold accelerator pedal partially open (1/4 throttle). For PFI or TBI cars do not depress throttle.

If car fails to start in 10 seconds, turn the key off (lock position), wait 5 seconds and try again. If car does not start in 5 seconds of additional cranking, try to relieve flooded condition (WOT for carbureted cars, 3/4 - WOT for injected cars). Cranking times greater than 15 seconds will be
considered a no start. Record 20 in the start time column to indicate this condition. Otherwise, record total cranking time (15 seconds or less).

2.Record idle quality (T, M, H) or a dash (-) if satisfactory in neutral (5 seconds).

3.Record idle quality in drive (5 seconds). If car stalls during any of these steps, restart (do not time restart) and go to the next step. Record number of stalls. Do not allow the car to stall more than three times.

4.Access track; stop. Make three short, sharp, light-throttle, 0-5 MPH accelerations, with a 5-second idle in drive after each of the accelerations. Record any malfunctions and rate idle quality.

5.Make a light-throttle 0-25 MPH acceleration. Record any malfunctions. Decelerate to a stop.

6.Make a 0-60 MPH WOT acceleration. Observer is to time acceleration. Rate and record severity of any malfunctions (T, M, H).

7.Complete loop of track to soak shelters. Pull into soak shelter. Idle in drive for 10 minutes and record idle quality at end of soak.

8.Back out of shelter (light-throttle) about 40 feet. Rate malfunctions noted. It may be necessary to turn wheel during this maneuver to provide easy access to track.

9.Shift to drive, rate idle.

10.Repeat Steps 4-6.

11.Complete loop of track to soak shelters. Pull into soak shelter. Shut off car for 20-minute hot soak.

12.Back out of shelter (light-throttle about 40 feet). Rate malfunctions noted. It may be necessary to turn wheel during this maneuver to provide easy access to track.

13.Repeat Steps 4-6.

14.Return car to fueling area.

Page ___

Test No.: ___

iicle No.: ___ Fuel No.: ___ Warmup Driver: ___
:e: ___ Gallons: ___ Test Driver: ___
Observer: ___

| | Time | Odometer | Temp |
|---|---|---|---|
| irt of Warmup | ___ | ___ | ___ |
| irt of Soak | ___ | ___ | ___ |
| l of Test | ___ | ___ | ___ |

Intended Test:
High Temp: ___
Intermediate: ___

| | Time Sec | | Idle | | | | Driving | | |
|---|---|---|---|---|---|---|---|---|---|
| iuever | 1st Try | 2nd Try | Rough | Stall | Hesit | Stum | Surge | B Fire | Stall |
| ;e Start | ___ | ___ | | | | | | | |
| lle (N) | | | ___ | ___ | | | | | |
| lle (D) | | | ___ | ___ | | | | | |
| 0-5 | | | | | ___ | ___ | ___ | ___ | ___ |
| dle | | | ___ | ___ | | | | | |
| 0-5 | | | | | ___ | ___ | ___ | ___ | ___ |
| dle | | | ___ | ___ | | | | | |
| 0-5 | | | | | ___ | ___ | ___ | ___ | ___ |
| dle | | | ___ | ___ | | | | | |
| -25 | | | | | ___ | ___ | ___ | ___ | ___ |
| -60 | ___ | | | | ___ | ___ | ___ | ___ | ___ |
| le Soak 10 Min Drive | | | ___ | ___ | | | | | |
| ck-up Lt Throt | | | | | ___ | ___ | ___ | ___ | ___ |
| le D | | | ___ | ___ | | | | | |
| -5 | | | | | ___ | ___ | ___ | ___ | ___ |
| le | | | ___ | ___ | | | | | |
| -5 | | | | | ___ | ___ | ___ | ___ | ___ |
| le | | | ___ | ___ | | | | | |
| -5 | | | | | ___ | ___ | ___ | ___ | ___ |
| le | | | ___ | ___ | | | | | |
| -25 | | | | | ___ | ___ | ___ | ___ | ___ |
| -60 | ___ | | | | ___ | ___ | ___ | ___ | ___ |
| Soak | ___ | ___ | | | | | | | |
| :k-up Lt Throt | | | | | ___ | ___ | ___ | ___ | ___ |
| ·5 | | | | | ___ | ___ | ___ | ___ | ___ |
| le | | | ___ | ___ | | | | | |
| ·5 | | | | | ___ | ___ | ___ | ___ | ___ |
| .e | | | ___ | ___ | | | | | |
| ·5 | | | | | ___ | ___ | ___ | ___ | ___ |
| e | | | ___ | ___ | | | | | |
| ·25 | | | | | ___ | ___ | ___ | ___ | ___ |
| 60 | ___ | | | | ___ | ___ | ___ | ___ | ___ |

# APPENDIX H

# DATA LISTING

| Vehicle | Fuel | Temperature | TWD | Sqrt TWD | Occurance Major Malfunction | Rater | Site | Date |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 87.67 | 99 | 9.95 | 4 | CPC | Denver | 7/14/92 |
| 1 | 1 | 68.67 | [illegible] | 9.27 | 2 | CPC | Denver | 7/20/92 |
| 1 | 1 | 75.33 | 124 | 11.14 | 6 | CPC | Denver | 7/20/92 |
| 1 | 1 | 91.00 | 85 | 9.22 | 4 | KCC | Denver | 7/28/92 |
| 1 | 1 | 79.00 | 141 | 11.87 | 10 | CPC | Denver | 7/29/92 |
| 1 | 1 | 98.00 | 113 | 10.63 | 4 | CPC | Phoenix | 8/11/92 |
| 1 | 1 | 93.67 | 129 | 11.36 | 6 | CPC | Phoenix | 8/19/92 |
| 1 | 1 | 88.33 | 142 | 11.92 | 8 | CPC | Phoenix | 8/20/92 |
| 1 | 10 | 70.67 | 93 | 9.64 | 4 | CPC | Denver | 7/24/92 |
| 1 | 10 | 87.67 | 97 | 9.85 | 4 | CPC | Denver | 7/24/92 |
| 1 | 11 | 61.67 | 51 | 7.14 | 0 | CPC | Denver | 7/21/92 |
| 1 | 11 | 77.00 | 52 | 7.21 | 2 | CPC | Denver | 7/22/92 |
| 1 | 11 | 94.67 | 91 | 9.54 | 2 | CPC | Phoenix | 8/18/92 |
| 1 | 11 | 102.33 | 131 | 11.45 | 4 | CPC | Phoenix | 8/20/92 |
| 1 | 12 | 72.00 | 129 | 11.36 | 5 | KCC | Denver | 7/17/92 |
| 1 | 12 | 82.17 | 83 | 9.11 | 4 | CPC | Denver | 7/22/92 |
| 1 | 13 | 105.33 | 155 | 12.45 | 8 | CPC | Phoenix | 8/13/92 |
| 1 | 13 | 98.67 | 110 | 10.49 | 4 | CPC | Phoenix | 8/17/92 |
| 1 | 13 | 86.00 | 97 | 9.85 | 4 | CPC | Phoenix | 8/21/92 |
| 1 | 13A | 71.67 | 65 | 8.06 | 2 | CPC | Denver | 7/28/92 |
| 1 | 13A | 81.00 | 107 | 10.34 | 4 | CPC | Denver | 7/28/92 |
| 1 | 13A | 72.33 | 107 | 10.34 | 4 | CPC | Denver | 7/29/92 |
| 1 | 14 | 82.77 | 103 | 10.15 | 4 | CPC | Denver | 7/08/92 |
| 1 | 14 | 67.17 | 88 | 9.38 | 4 | CPC | Denver | 7/16/92 |
| 1 | 15 | 83.67 | 74 | 8.60 | 2 | CPC | Denver | 7/09/92 |
| 1 | 15 | 77.00 | 147 | 12.12 | 7 | CPC | Denver | 7/21/92 |
| 1 | 15 | 77.00 | 60 | 7.75 | 2 | CPC | Denver | 7/30/92 |
| 1 | 15 | 98.67 | 99 | 9.95 | 4 | CPC | Phoenix | 8/31/92 |
| 1 | 15 | 94.00 | 81 | 9.00 | 4 | CPC | Phoenix | 9/03/92 |
| 1 | 16 | 81.67 | 67 | 8.19 | 2 | CPC | Denver | 7/27/92 |
| 1 | 16 | 70.67 | 68 | 8.25 | 2 | CPC | Denver | 7/30/92 |
| 1 | 17 | 66.00 | 100 | 10.00 | 5 | CPC | Denver | 7/22/92 |
| 1 | 17 | 86.00 | 93 | 9.64 | 2 | CPC | Denver | 7/28/92 |
| 1 | 17 | 101.67 | 105 | 10.25 | 2 | CPC | Phoenix | 8/18/92 |
| 1 | 17 | 96.67 | 144 | 12.00 | 6 | CPC | Phoenix | 8/20/92 |
| 1 | 18 | 79.67 | 100 | 10.00 | 4 | CPC | Denver | 7/21/92 |
| 1 | 18 | 73.33 | 75 | 8.66 | 2 | CPC | Denver | 7/26/92 |
| 1 | 2 | 66.00 | 102 | 10.10 | 4 | CPC | Denver | 7/16/92 |
| 1 | 2 | 77.00 | 123 | 11.09 | 4 | CPC | Denver | 7/23/92 |
| 1 | 2 | 89.00 | 86 | 9.27 | 4 | CPC | Phoenix | 8/12/92 |
| 1 | 2 | 79.33 | 96 | 9.80 | 4 | CPC | Phoenix | 8/24/92 |
| 1 | 3 | 79.33 | 133 | 11.53 | 6 | CPC | Denver | 7/26/92 |
| 1 | 3 | 65.67 | 95 | 9.75 | 4 | CPC | Denver | 7/27/92 |
| 1 | 3 | 80.00 | 66 | 8.12 | 2 | CPC | Denver | 7/30/92 |
| 1 | 3 | 95.33 | 124 | 11.14 | 4 | CPC | Phoenix | 8/21/92 |
| 1 | 3 | 94.33 | 89 | 9.43 | 4 | CPC | Phoenix | 8/31/92 |
| 1 | 4 | 89.00 | 188 | 13.71 | 10 | CPC | Denver | 7/27/92 |
| 1 | 4 | 65.33 | 83 | 9.11 | 2 | CPC | Denver | 7/29/92 |
| 1 | 5 | 79.50 | 76 | 8.72 | 2 | CPC | Denver | 7/10/92 |
| 1 | 5 | 73.67 | 71 | 8.43 | 2 | CPC | Denver | 7/13/92 |
| 1 | 5 | 105.67 | 121 | 11.00 | 4 | CPC | Phoenix | 8/12/92 |
| 1 | 5 | 99.33 | 115 | 10.72 | 2 | CPC | Phoenix | 8/19/92 |
| 1 | 6 | 60.33 | 67 | 8.19 | 2 | CPC | Denver | 7/17/92 |
| 1 | 6 | 84.67 | 121 | 11.00 | 4 | CPC | Denver | 7/23/92 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 7 | 86.83 | 129 | 11.36 | 4 | CPC | Denver | 7/11/92 |
| 1 | 7 | 78.00 | 108 | 10.39 | 4 | CPC | Denver | 7/20/92 |
| 1 | 7 | 76.00 | 70 | 8.37 | 4 | CPC | Denver | 7/29/92 |
| 1 | 7 | 102.00 | 146 | 12.08 | 7 | CPC | Phoenix | 8/14/92 |
| 1 | 7 | 106.67 | 126 | 11.22 | 6 | CPC | Phoenix | 8/17/92 |
| 1 | 8 | 85.00 | 81 | 9.00 | 2 | CPC | Denver | 7/07/92 |
| 1 | 8 | 63.50 | 77 | 8.77 | 2 | CPC | Denver | 7/16/92 |
| 1 | 8 | 82.67 | 102 | 10.10 | 4 | CPC | Phoenix | 8/24/92 |
| 1 | 9 | 62.33 | 74 | 8.60 | 2 | CPC | Denver | 7/23/92 |
| 1 | 9 | 79.17 | 80 | 8.94 | 2 | CPC | Denver | 7/24/92 |
| 1 | 9 | 81.67 | 70 | 8.37 | 2 | CPC | Denver | 7/30/92 |
| 1 | 9 | 84.67 | 103 | 10.15 | 4 | CPC | Phoenix | 8/21/92 |
| 1 | 9 | 88.33 | 113 | 10.63 | 6 | CPC | Phoenix | 8/31/92 |
| 2 | 1 | 90.33 | 22 | 4.69 | 0 | KCC | Denver | 7/14/92 |
| 2 | 1 | 77.67 | 9 | 3.00 | 0 | KCC | Denver | 7/20/92 |
| 2 | 1 | 76.33 | 14 | 3.74 | 0 | KCC | Denver | 7/29/92 |
| 2 | 1 | 102.33 | 68 | 8.25 | 2 | JR | Phoenix | 8/12/92 |
| 2 | 1 | 99.17 | 36 | 6.00 | 2 | CJB | Phoenix | 8/19/92 |
| 2 | 1 | 89.67 | 35 | 5.92 | 2 | CJB | Phoenix | 8/20/92 |
| 2 | 10 | 71.83 | 41 | 6.40 | 2 | KCC | Denver | 7/24/92 |
| 2 | 10 | 82.67 | 67 | 8.19 | 4 | KCC | Denver | 7/24/92 |
| 2 | 11 | 61.33 | 8 | 2.83 | 0 | KCC | Denver | 7/21/92 |
| 2 | 11 | 83.00 | 8 | 2.83 | 0 | KCC | Denver | 7/22/92 |
| 2 | 11 | 102.67 | 48 | 6.93 | 2 | CJB | Phoenix | 8/18/92 |
| 2 | 11 | 97.83 | 41 | 6.40 | 2 | CJB | Phoenix | 8/20/92 |
| 2 | 12 | 68.00 | 27 | 5.20 | 2 | JER | Denver | 7/17/92 |
| 2 | 12 | 78.33 | 54 | 7.35 | 4 | KCC | Denver | 7/22/92 |
| 2 | 13 | 105.67 | 43 | 6.56 | 2 | JR | Phoenix | 8/14/92 |
| 2 | 13 | 105.33 | 58 | 7.62 | 2 | CJB | Phoenix | 8/17/92 |
| 2 | 13A | 73.00 | 20 | 4.47 | 0 | KCC | Denver | 7/28/92 |
| 2 | 13A | 87.33 | 86 | 9.27 | 4 | KCC | Denver | 7/28/92 |
| 2 | 13A | 79.33 | 22 | 4.69 | 0 | KCC | Denver | 7/29/92 |
| 2 | 13A | 85.17 | 36 | 6.00 | 2 | CJB | Phoenix | 8/21/92 |
| 2 | 14 | 84.67 | 27 | 5.20 | 2 | KCC | Denver | 7/07/92 |
| 2 | 14 | 63.17 | 30 | 5.48 | 2 | KCC | Denver | 7/16/92 |
| 2 | 15 | 85.50 | 70 | 8.37 | 4 | KCC | Denver | 7/09/92 |
| 2 | 15 | 77.33 | 11 | 3.32 | 0 | KCC | Denver | 7/21/92 |
| 2 | 15 | 78.67 | 39 | 6.24 | 2 | KCC | Denver | 7/30/92 |
| 2 | 15 | 94.67 | 24 | 4.90 | 2 | CJB | Phoenix | 8/31/92 |
| 2 | 15 | 94.67 | 19 | 4.36 | 0 | CJB | Phoenix | 9/03/92 |
| 2 | 16 | 88.67 | 52 | 7.21 | 2 | KCC | Denver | 7/27/92 |
| 2 | 16 | 69.33 | 40 | 6.32 | 2 | KCC | Denver | 7/30/92 |
| 2 | 17 | 67.33 | 7 | 2.65 | 0 | KCC | Denver | 7/22/92 |
| 2 | 17 | 83.00 | 14 | 3.74 | 0 | KCC | Denver | 7/28/92 |
| 2 | 17 | 95.00 | 49 | 7.00 | 0 | CJB | Phoenix | 8/18/92 |
| 2 | 17 | 101.67 | 30 | 5.48 | 2 | CJB | Phoenix | 8/20/92 |
| 2 | 18 | 79.00 | 55 | 7.42 | 4 | KCC | Denver | 7/21/92 |
| 2 | 18 | 81.00 | 62 | 7.87 | 4 | KCC | Denver | 7/26/92 |
| 2 | 2 | 65.67 | 5 | 2.24 | 0 | KCC | Denver | 7/16/92 |
| 2 | 2 | 84.00 | 69 | 8.31 | 4 | KCC | Denver | 7/23/92 |
| 2 | 2 | 88.67 | 64 | 8.00 | 4 | JR | Phoenix | 8/12/92 |
| 2 | 2 | 84.33 | 60 | 7.75 | 4 | CJB | Phoenix | 8/24/92 |
| 2 | 3 | 74.67 | 14 | 3.74 | 0 | KCC | Denver | 7/26/92 |
| 2 | 3 | 67.33 | 12 | 3.46 | 0 | KCC | Denver | 7/27/92 |
| 2 | 3 | 83.33 | 19 | 4.36 | 0 | KCC | Denver | 7/30/92 |
| 2 | 3 | 85.17 | 19 | 4.36 | 0 | CJB | Phoenix | 8/21/92 |
| 2 | 3 | 99.00 | 25 | 5.00 | 2 | CJB | Phoenix | 8/31/92 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2 | 3 | 97.00 | 25 | 5.00 | 2 | CJB | Phoenix | 9/03/92 |
| 2 | 4 | 80.33 | 64 | 8.00 | 4 | KCC | Denver | 7/27/92 |
| 2 | 4 | 65.33 | 16 | 4.00 | 0 | KCC | Denver | 7/29/92 |
| 2 | 5 | 79.33 | 7 | 2.65 | 0 | KCC | Denver | 7/10/92 |
| 2 | 5 | 75.17 | 8 | 2.83 | 0 | KCC | Denver | 7/13/92 |
| 2 | 5 | 98.67 | 85 | 9.22 | 4 | JR | Phoenix | 8/11/92 |
| 2 | 5 | 93.67 | 22 | 4.69 | 0 | CJB | Phoenix | 8/19/92 |
| 2 | 6 | 60.67 | 28 | 5.29 | 2 | KCC | Denver | 7/17/92 |
| 2 | 6 | 78.33 | 58 | 7.62 | 4 | KCC | Denver | 7/23/92 |
| 2 | 7 | 88.33 | 21 | 4.58 | 0 | KCC | Denver | 7/11/92 |
| 2 | 7 | 70.00 | 15 | 3.87 | 1 | KCC | Denver | 7/20/92 |
| 2 | 7 | 72.67 | 14 | 3.74 | 0 | KCC | Denver | 7/29/92 |
| 2 | 7 | 104.67 | 82 | 9.06 | 4 | JR | Phoenix | 8/13/92 |
| 2 | 7 | 99.33 | 81 | 9.00 | 4 | CJB | Phoenix | 8/17/92 |
| 2 | 8 | 84.67 | 61 | 7.81 | 4 | KCC | Denver | 7/08/92 |
| 2 | 8 | 68.50 | 20 | 4.47 | 0 | KCC | Denver | 7/16/92 |
| 2 | 8 | 79.00 | 30 | 5.48 | 0 | CJB | Phoenix | 8/24/92 |
| 2 | 9 | 62.83 | 11 | 3.32 | 0 | KCC | Denver | 7/23/92 |
| 2 | 9 | 88.00 | 46 | 6.78 | 2 | KCC | Denver | 7/24/92 |
| 2 | 9 | 77.33 | 20 | 4.47 | 0 | KCC | Denver | 7/30/92 |
| 2 | 9 | 94.33 | 26 | 5.10 | 0 | CJB | Phoenix | 8/21/92 |
| 2 | 9 | 89.00 | 24 | 4.90 | 2 | CJB | Phoenix | 8/31/92 |
| 3 | 1 | 89.67 | 59 | 7.68 | 4 | JER | Denver | 7/14/92 |
| 3 | 1 | 69.67 | 55 | 7.42 | 4 | JER | Denver | 7/20/92 |
| 3 | 1 | 72.33 | 54 | 7.35 | 3 | JER | Denver | 7/29/92 |
| 3 | 1 | 99.33 | 59 | 7.68 | 2 | CJB | Phoenix | 8/11/92 |
| 3 | 1 | 94.67 | 52 | 7.21 | 3 | JR | Phoenix | 8/19/92 |
| 3 | 10 | 72.67 | 40 | 6.32 | 0 | JER | Denver | 7/24/92 |
| 3 | 10 | 87.67 | 105 | 10.25 | 6 | JER | Denver | 7/24/92 |
| 3 | 11 | 64.33 | 26 | 5.10 | 0 | JER | Denver | 7/21/92 |
| 3 | 11 | 75.67 | 37 | 6.08 | 0 | JER | Denver | 7/22/92 |
| 3 | 11 | 94.67 | 54 | 7.35 | 2 | JR | Phoenix | 8/18/92 |
| 3 | 11 | 102.33 | 47 | 6.86 | 1 | JR | Phoenix | 8/20/92 |
| 3 | 12 | 68.67 | 40 | 6.32 | 0 | CPC | Denver | 7/17/92 |
| 3 | 12 | 81.33 | 92 | 9.59 | 6 | JER | Denver | 7/22/92 |
| 3 | 13 | 105.33 | 82 | 9.06 | 5 | CJB | Phoenix | 8/13/92 |
| 3 | 13 | 99.33 | 43 | 6.56 | 2 | JR | Phoenix | 8/17/92 |
| 3 | 13 | 85.00 | 26 | 5.10 | 0 | JR | Phoenix | 8/21/92 |
| 3 | 13A | 72.67 | 56 | 7.48 | 4 | JER | Denver | 7/28/92 |
| 3 | 13A | 83.67 | 55 | 7.42 | 4 | JER | Denver | 7/28/92 |
| 3 | 13A | 76.00 | 58 | 7.62 | 4 | JER | Denver | 7/29/92 |
| 3 | 14 | 84.67 | 94 | 9.70 | 4 | CPC | Denver | 7/07/92 |
| 3 | 14 | 67.33 | 44 | 6.63 | 2 | JER | Denver | 7/16/92 |
| 3 | 15 | 83.67 | 32 | 5.66 | 0 | CPC | Denver | 7/09/92 |
| 3 | 15 | 77.33 | 31 | 5.57 | 0 | JER | Denver | 7/21/92 |
| 3 | 15 | 81.00 | 57 | 7.55 | 4 | JER | Denver | 7/30/92 |
| 3 | 15 | 90.00 | 32 | 5.66 | 0 | JR | Phoenix | 8/31/92 |
| 3 | 15 | 94.00 | 38 | 6.16 | 2 | JR | Phoenix | 9/03/92 |
| 3 | 16 | 82.67 | 101 | 10.05 | 6 | JER | Denver | 7/27/92 |
| 3 | 16 | 69.33 | 31 | 5.57 | 0 | JER | Denver | 7/30/92 |
| 3 | 17 | 68.00 | 31 | 5.57 | 0 | JER | Denver | 7/22/92 |
| 3 | 17 | 89.67 | 63 | 7.94 | 4 | JER | Denver | 7/28/92 |
| 3 | 17 | 103.67 | 65 | 8.06 | 2 | JR | Phoenix | 8/18/92 |
| 3 | 17 | 98.33 | 37 | 6.08 | 1 | JR | Phoenix | 8/20/92 |
| 3 | 18 | 81.67 | 81 | 9.00 | 4 | JER | Denver | 7/21/92 |
| 3 | 18 | 74.67 | 56 | 7.48 | 2 | JER | Denver | 7/26/92 |
| 3 | 2 | 65.17 | 68 | 8.25 | 4 | JER | Denver | 7/16/92 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 3 | 2 | 79.67 | 110 | 10.49 | 6 | JER | Denver | 7/23/92 |
| 3 | 2 | 90.83 | 68 | 8.25 | 4 | CJB | Phoenix | 8/12/92 |
| 3 | 2 | 78.67 | 33 | 5.74 | 0 | JR | Phoenix | 8/24/92 |
| 3 | 3 | 80.67 | 55 | 7.42 | 4 | JER | Denver | 7/26/92 |
| 3 | 3 | 68.00 | 56 | 7.48 | 4 | JER | Denver | 7/27/92 |
| 3 | 3 | 77.33 | 44 | 6.63 | 2 | JER | Denver | 7/30/92 |
| 3 | 3 | 93.33 | 40 | 6.32 | 3 | JR | Phoenix | 8/21/92 |
| 3 | 3 | 95.33 | 45 | 6.71 | 2 | JR | Phoenix | 8/31/92 |
| 3 | 4 | 90.00 | 108 | 10.39 | 6 | JER | Denver | 7/27/92 |
| 3 | 4 | 66.67 | 44 | 6.63 | 2 | JER | Denver | 7/29/92 |
| 3 | 5 | 84.00 | 37 | 6.08 | 0 | CPC | Denver | 7/10/92 |
| 3 | 5 | 74.33 | 32 | 5.66 | 0 | JER | Denver | 7/13/92 |
| 3 | 5 | 105.33 | 106 | 10.30 | 6 | CJB | Phoenix | 8/12/92 |
| 3 | 5 | 100.33 | 46 | 6.78 | 3 | JR | Phoenix | 8/19/92 |
| 3 | 6 | 61.00 | 31 | 5.57 | 1 | JER | Denver | 7/17/92 |
| 3 | 6 | 84.33 | 92 | 9.59 | 6 | JER | Denver | 7/23/92 |
| 3 | 7 | 79.33 | 36 | 6.00 | 0 | CPC | Denver | 7/11/92 |
| 3 | 7 | 77.33 | 31 | 5.57 | 0 | JER | Denver | 7/20/92 |
| 3 | 7 | 80.33 | 54 | 7.35 | 2 | JER | Denver | 7/29/92 |
| 3 | 7 | 104.67 | 85 | 9.22 | 6 | CJB | Phoenix | 8/14/92 |
| 3 | 7 | 107.00 | 83 | 9.11 | 5 | JR | Phoenix | 8/17/92 |
| 3 | 8 | 70.93 | 57 | 7.55 | 0 | CPC | Denver | 7/08/92 |
| 3 | 8 | 63.00 | 38 | 6.16 | 0 | JER | Denver | 7/16/92 |
| 3 | 8 | 83.00 | 27 | 5.20 | 0 | JR | Phoenix | 8/24/92 |
| 3 | 9 | 63.67 | 31 | 5.57 | 0 | JER | Denver | 7/23/92 |
| 3 | 9 | 83.00 | 85 | 9.22 | 5 | JER | Denver | 7/24/92 |
| 3 | 9 | 78.33 | 44 | 6.63 | 2 | JER | Denver | 7/30/92 |
| 3 | 9 | 85.67 | 61 | 7.81 | 2 | JR | Phoenix | 8/21/92 |
| 3 | 9 | 98.67 | 10 | 3.16 | 0 | JR | Phoenix | 8/31/92 |
| 4 | 1 | 86.33 | 70 | 8.37 | 2 | CPC | Denver | 7/14/92 |
| 4 | 1 | 72.00 | 49 | 7.00 | 0 | CPC | Denver | 7/20/92 |
| 4 | 1 | 80.67 | 91 | 9.54 | 0 | CPC | Denver | 7/29/92 |
| 4 | 1 | 102.33 | 205 | 14.32 | 14 | CPC | Phoenix | 8/11/92 |
| 4 | 1 | 104.00 | 226 | 15.03 | 18 | CPC | Phoenix | 8/19/92 |
| 4 | 1 | 91.33 | 131 | 11.45 | 4 | CPC | Phoenix | 8/19/92 |
| 4 | 10 | 74.33 | 80 | 8.94 | 0 | CPC | Denver | 7/24/92 |
| 4 | 10 | 89.00 | 91 | 9.54 | 2 | CPC | Denver | 7/24/92 |
| 4 | 11 | 66.33 | 19 | 4.36 | 0 | CPC | Denver | 7/21/92 |
| 4 | 11 | 79.67 | 45 | 6.71 | 0 | CPC | Denver | 7/22/92 |
| 4 | 11 | 105.33 | 134 | 11.58 | 6 | CPC | Phoenix | 8/18/92 |
| 4 | 11 | 102.67 | 118 | 10.86 | 2 | CPC | Phoenix | 8/20/92 |
| 4 | 12 | 72.50 | 59 | 7.68 | 2 | KCC | Denver | 7/17/92 |
| 4 | 12 | 83.00 | 52 | 7.21 | 0 | CPC | Denver | 7/22/92 |
| 4 | 13 | 98.00 | 172 | 13.11 | 12 | CPC | Phoenix | 8/13/92 |
| 4 | 13 | 108.00 | 254 | 15.94 | 19 | CPC | Phoenix | 8/17/92 |
| 4 | 13A | 76.33 | 81 | 9.00 | 0 | CPC | Denver | 7/28/92 |
| 4 | 13A | 85.00 | 104 | 10.20 | 0 | CPC | Denver | 7/28/92 |
| 4 | 13A | 73.00 | 64 | 8.00 | 0 | CPC | Denver | 7/29/92 |
| 4 | 14 | 82.33 | 97 | 9.85 | 3 | KCC | Denver | 7/07/92 |
| 4 | 14 | 66.67 | 48 | 6.93 | 0 | CPC | Denver | 7/16/92 |
| 4 | 15 | 83.50 | 93 | 9.64 | 0 | KCC | Denver | 7/09/92 |
| 4 | 15 | 78.00 | 69 | 8.31 | 2 | CPC | Denver | 7/21/92 |
| 4 | 15 | 77.33 | 83 | 9.11 | 0 | CPC | Denver | 7/30/92 |
| 4 | 15 | 99.67 | 74 | 8.60 | 0 | CPC | Phoenix | 8/31/92 |
| 4 | 15 | 93.67 | 100 | 10.00 | 2 | CPC | Phoenix | 9/03/92 |
| 4 | 16 | 85.00 | 67 | 8.19 | 0 | CPC | Denver | 7/27/92 |
| 4 | 16 | 68.33 | 56 | 7.48 | 0 | CPC | Denver | 7/30/92 |

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|---|---|---|---|---|---|---|---|---|
| 4 | 17 | 68.67 | 58 | 7.62 | 0 | CPC | Denver | 7/22/92 |
| 4 | 17 | 89.33 | 81 | 9.00 | 0 | CPC | Denver | 7/28/92 |
| 4 | 17 | 100.33 | 127 | 11.27 | 4 | CPC | Phoenix | 8/18/92 |
| 4 | 17 | 95.33 | 128 | 11.31 | 4 | CPC | Phoenix | 8/20/92 |
| 4 | 18 | 78.33 | 74 | 8.60 | 2 | CPC | Denver | 7/21/92 |
| 4 | 18 | 77.67 | 87 | 9.33 | 0 | CPC | Denver | 7/26/92 |
| 4 | 2 | 63.33 | 59 | 7.68 | 0 | CPC | Denver | 7/16/92 |
| 4 | 2 | 81.67 | 68 | 8.25 | 0 | CPC | Denver | 7/23/92 |
| 4 | 2 | 85.33 | 72 | 8.49 | 2 | CPC | Phoenix | 8/24/92 |
| 4 | 3 | 82.00 | 71 | 8.43 | 0 | CPC | Denver | 7/26/92 |
| 4 | 3 | 71.33 | 61 | 7.81 | 0 | CPC | Denver | 7/27/92 |
| 4 | 3 | 80.67 | 90 | 9.49 | 0 | CPC | Denver | 7/30/92 |
| 4 | 3 | 93.67 | 122 | 11.05 | 4 | CPC | Phoenix | 8/21/92 |
| 4 | 3 | 89.67 | 98 | 9.90 | 0 | CPC | Phoenix | 8/31/92 |
| 4 | 4 | 92.33 | 132 | 11.49 | 4 | CPC | Denver | 7/27/92 |
| 4 | 4 | 70.00 | 65 | 8.06 | 0 | CPC | Denver | 7/29/92 |
| 4 | 5 | 86.50 | 89 | 9.43 | 0 | KCC | Denver | 7/10/92 |
| 4 | 5 | 76.67 | 47 | 6.86 | 0 | CPC | Denver | 7/13/92 |
| 4 | 5 | 98.67 | 174 | 13.19 | 12 | CPC | Phoenix | 8/12/92 |
| 4 | 5 | 97.33 | 97 | 9.85 | 0 | CPC | Phoenix | 8/19/92 |
| 4 | 6 | 63.67 | 32 | 5.66 | 0 | CPC | Denver | 7/17/92 |
| 4 | 6 | 83.00 | 112 | 10.58 | 4 | CPC | Denver | 7/23/92 |
| 4 | 7 | 81.33 | 111 | 10.54 | 1 | KCC | Denver | 7/11/92 |
| 4 | 7 | 77.00 | 53 | 7.28 | 0 | CPC | Denver | 7/20/92 |
| 4 | 7 | 78.67 | 91 | 9.54 | 0 | CPC | Denver | 7/29/92 |
| 4 | 7 | 96.67 | 149 | 12.21 | 3 | CPC | Phoenix | 8/14/92 |
| 4 | 7 | 103.67 | 199 | 14.11 | 9 | CPC | Phoenix | 8/17/92 |
| 4 | 8 | 72.00 | 82 | 9.06 | 0 | KCC | Denver | 7/08/92 |
| 4 | 8 | 62.00 | 53 | 7.28 | 0 | CPC | Denver | 7/16/92 |
| 4 | 8 | 83.00 | 79 | 8.89 | 0 | CPC | Phoenix | 8/24/92 |
| 4 | 9 | 67.00 | 73 | 8.54 | 2 | CPC | Denver | 7/23/92 |
| 4 | 9 | 85.33 | 84 | 9.17 | 0 | CPC | Denver | 7/24/92 |
| 4 | 9 | 84.33 | 55 | 7.42 | 0 | CPC | Phoenix | 8/21/92 |
| 4 | 9 | 96.00 | 83 | 9.11 | 0 | CPC | Phoenix | 8/31/92 |
| 5 | 1 | 86.67 | 45 | 6.71 | 1 | KCC | Denver | 7/14/92 |
| 5 | 1 | 78.67 | 18 | 4.24 | 0 | KCC | Denver | 7/20/92 |
| 5 | 1 | 79.00 | 29 | 5.39 | 1 | KCC | Denver | 7/29/92 |
| 5 | 1 | 99.33 | 28 | 5.29 | 1 | JR | Phoenix | 8/12/92 |
| 5 | 1 | 92.17 | 36 | 6.00 | 0 | CJB | Phoenix | 8/19/92 |
| 5 | 1 | 102.17 | 28 | 5.29 | 0 | CJB | Phoenix | 8/19/92 |
| 5 | 10 | 75.33 | 66 | 8.12 | 1 | KCC | Denver | 7/24/92 |
| 5 | 10 | 86.33 | 77 | 8.77 | 2 | KCC | Denver | 7/24/92 |
| 5 | 11 | 66.67 | 11 | 3.32 | 1 | KCC | Denver | 7/21/92 |
| 5 | 11 | 82.00 | 15 | 3.87 | 0 | KCC | Denver | 7/22/92 |
| 5 | 11 | 105.50 | 66 | 8.12 | 3 | CJB | Phoenix | 8/18/92 |
| 5 | 11 | 100.83 | 26 | 5.10 | 0 | CJB | Phoenix | 8/20/92 |
| 5 | 12 | 72.17 | 73 | 8.54 | 2 | JER | Denver | 7/17/92 |
| 5 | 12 | 80.67 | 50 | 7.07 | 1 | KCC | Denver | 7/22/92 |
| 5 | 13 | 83.33 | 59 | 7.68 | 1 | CPC | Denver | 7/11/92 |
| 5 | 13 | 98.67 | 16 | 4.00 | 0 | JR | Phoenix | 8/14/92 |
| 5 | 13 | 108.67 | 78 | 8.83 | 3 | CJB | Phoenix | 8/17/92 |
| 5 | 13A | 77.67 | 21 | 4.58 | 0 | KCC | Denver | 7/28/92 |
| 5 | 13A | 89.33 | 54 | 7.35 | 0 | KCC | Denver | 7/28/92 |
| 5 | 13A | 73.67 | 27 | 5.20 | 0 | KCC | Denver | 7/30/92 |
| 5 | 14 | 80.33 | 67 | 8.19 | 0 | CPC | Denver | 7/08/92 |
| 5 | 14 | 64.00 | 8 | 2.83 | 0 | KCC | Denver | 7/16/92 |
| 5 | 15 | 78.33 | 13 | 3.61 | 0 | KCC | Denver | 7/21/92 |

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|---|---|---|---|---|---|---|---|---|
| 5 | 15 | 80.67 | 26 | 5.10 | 0 | KCC | Denver | 7/30/92 |
| 5 | 15 | 96.67 | 20 | 4.47 | 0 | CJB | Phoenix | 8/31/92 |
| 5 | 15 | 94.33 | 19 | 4.36 | 0 | CJB | Phoenix | 9/03/92 |
| 5 | 16 | 91.33 | 126 | 11.22 | 4 | KCC | Denver | 7/27/92 |
| 5 | 16 | 67.33 | 15 | 3.87 | 0 | KCC | Denver | 7/30/92 |
| 5 | 17 | 70.67 | 2 | 1.41 | 0 | KCC | Denver | 7/22/92 |
| 5 | 17 | 84.00 | 13 | 3.61 | 0 | KCC | Denver | 7/28/92 |
| 5 | 17 | 99.00 | 59 | 7.68 | 4 | CJB | Phoenix | 8/18/92 |
| 5 | 17 | 95.00 | 32 | 5.66 | 0 | CJB | Phoenix | 8/20/92 |
| 5 | 18 | 80.67 | 50 | 7.07 | 0 | KCC | Denver | 7/21/92 |
| 5 | 18 | 83.00 | 104 | 10.20 | 0 | KCC | Denver | 7/26/92 |
| 5 | 2 | 65.00 | 18 | 4.24 | 0 | KCC | Denver | 7/16/92 |
| 5 | 2 | 80.00 | 49 | 7.00 | 2 | CJB | Phoenix | 8/24/92 |
| 5 | 3 | 77.33 | 55 | 7.42 | 0 | KCC | Denver | 7/26/92 |
| 5 | 3 | 71.33 | 13 | 3.61 | 0 | KCC | Denver | 7/27/92 |
| 5 | 3 | 89.83 | 55 | 7.42 | 4 | CJB | Phoenix | 8/21/92 |
| 5 | 3 | 98.67 | 29 | 5.39 | 0 | CJB | Phoenix | 8/31/92 |
| 5 | 4 | 86.33 | 106 | 10.30 | 4 | KCC | Denver | 7/27/92 |
| 5 | 4 | 75.33 | 42 | 6.48 | 0 | KCC | Denver | 7/29/92 |
| 5 | 5 | 82.00 | 42 | 6.48 | 0 | CPC | Denver | 7/10/92 |
| 5 | 5 | 77.67 | 47 | 6.86 | 0 | KCC | Denver | 7/13/92 |
| 5 | 5 | 101.67 | 25 | 5.00 | 0 | JR | Phoenix | 8/11/92 |
| 5 | 5 | 96.83 | 44 | 6.63 | 2 | CJB | Phoenix | 8/19/92 |
| 5 | 6 | 67.50 | 7 | 2.65 | 0 | KCC | Denver | 7/17/92 |
| 5 | 6 | 80.33 | 81 | 9.00 | 2 | KCC | Denver | 7/23/92 |
| 5 | 7 | 81.00 | 67 | 8.19 | 1 | CPC | Denver | 7/09/92 |
| 5 | 7 | 73.33 | 13 | 3.61 | 0 | KCC | Denver | 7/20/92 |
| 5 | 7 | 74.00 | 31 | 5.57 | 1 | KCC | Denver | 7/29/92 |
| 5 | 7 | 98.00 | 12 | 3.46 | 0 | JR | Phoenix | 8/13/92 |
| 5 | 7 | 102.67 | 34 | 5.83 | 0 | CJB | Phoenix | 8/17/92 |
| 5 | 8 | 82.67 | 90 | 9.49 | 4 | CPC | Denver | 7/13/92 |
| 5 | 8 | 67.33 | 14 | 3.74 | 1 | KCC | Denver | 7/16/92 |
| 5 | 8 | 88.00 | 28 | 5.29 | 0 | CJB | Phoenix | 8/24/92 |
| 5 | 9 | 68.83 | 11 | 3.32 | 0 | KCC | Denver | 7/23/92 |
| 5 | 9 | 91.00 | 46 | 6.78 | 1 | KCC | Denver | 7/24/92 |
| 5 | 9 | 78.00 | 16 | 4.00 | 0 | KCC | Denver | 7/30/92 |
| 5 | 9 | 84.50 | 31 | 5.57 | 0 | CJB | Phoenix | 8/21/92 |
| 5 | 9 | 90.67 | 15 | 3.87 | 0 | CJB | Phoenix | 8/31/92 |
| 6 | 1 | 87.17 | 36 | 6.00 | 0 | JER | Denver | 7/14/92 |
| 6 | 1 | 74.00 | 22 | 4.69 | 0 | JER | Denver | 7/20/92 |
| 6 | 1 | 75.00 | 44 | 6.63 | 0 | JER | Denver | 7/29/92 |
| 6 | 1 | 102.50 | 30 | 5.48 | 0 | CJB | Phoenix | 8/11/92 |
| 6 | 1 | 97.00 | 28 | 5.29 | 0 | JR | Phoenix | 8/19/92 |
| 6 | 1 | 92.33 | 22 | 4.69 | 0 | JR | Phoenix | 8/19/92 |
| 6 | 10 | 76.00 | 26 | 5.10 | 0 | JER | Denver | 7/24/92 |
| 6 | 10 | 91.33 | 30 | 5.48 | 2 | JER | Denver | 7/24/92 |
| 6 | 11 | 68.67 | 15 | 3.87 | 0 | JER | Denver | 7/21/92 |
| 6 | 11 | 81.17 | 11 | 3.32 | 0 | JER | Denver | 7/22/92 |
| 6 | 11 | 100.33 | 46 | 6.78 | 0 | JR | Phoenix | 8/18/92 |
| 6 | 11 | 93.67 | 19 | 4.36 | 0 | JR | Phoenix | 8/20/92 |
| 6 | 12 | 71.67 | 42 | 6.48 | 2 | CPC | Denver | 7/17/92 |
| 6 | 12 | 80.33 | 36 | 6.00 | 2 | JER | Denver | 7/22/92 |
| 6 | 13 | 84.00 | 27 | 5.20 | 0 | KCC | Denver | 7/11/92 |
| 6 | 13 | 99.67 | 39 | 6.24 | 0 | CJB | Phoenix | 8/13/92 |
| 6 | 13 | 103.33 | 31 | 5.57 | 1 | JR | Phoenix | 8/17/92 |
| 6 | 13A | 76.33 | 28 | 5.29 | 0 | JER | Denver | 7/28/92 |
| 6 | 13A | 85.00 | 49 | 7.00 | 2 | JER | Denver | 7/28/92 |

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|---|---|---|---|---|---|---|---|---|
| 6 | 13A | 79.33 | 31 | 5.57 | 0 | JER | Denver | 7/29/92 |
| 6 | 14 | 80.33 | 45 | 6.71 | 2 | KCC | Denver | 7/08/92 |
| 6 | 14 | 63.67 | 23 | 4.80 | 0 | JER | Denver | 7/16/92 |
| 6 | 15 | 78.67 | 25 | 5.00 | 1 | JER | Denver | 7/21/92 |
| 6 | 15 | 91.67 | 21 | 4.58 | 0 | JR | Phoenix | 8/31/92 |
| 6 | 15 | 94.00 | 26 | 5.10 | 0 | JR | Phoenix | 9/03/92 |
| 6 | 16 | 86.67 | 53 | 7.28 | 2 | JER | Denver | 7/27/92 |
| 6 | 16 | 66.33 | 35 | 5.92 | 0 | JER | Denver | 7/30/92 |
| 6 | 17 | 72.00 | 17 | 4.12 | 0 | JER | Denver | 7/22/92 |
| 6 | 17 | 89.67 | 52 | 7.21 | 0 | JER | Denver | 7/28/92 |
| 6 | 17 | 106.00 | 31 | 5.57 | 1 | JR | Phoenix | 8/18/92 |
| 6 | 17 | 101.33 | 22 | 4.69 | 1 | JR | Phoenix | 8/20/92 |
| 6 | 18 | 79.67 | 61 | 7.81 | 3 | JER | Denver | 7/21/92 |
| 6 | 18 | 78.00 | 27 | 5.20 | 0 | JER | Denver | 7/26/92 |
| 6 | 2 | 67.00 | 41 | 6.40 | 2 | JER | Denver | 7/16/92 |
| 6 | 2 | 80.67 | 39 | 6.24 | 2 | JER | Denver | 7/23/92 |
| 6 | 2 | 82.33 | 21 | 4.58 | 0 | JR | Phoenix | 8/24/92 |
| 6 | 3 | 85.00 | 49 | 7.00 | 1 | JER | Denver | 7/26/92 |
| 6 | 3 | 73.33 | 37 | 6.08 | 0 | JER | Denver | 7/27/92 |
| 6 | 3 | 80.00 | 43 | 6.56 | 0 | JER | Denver | 7/30/92 |
| 6 | 3 | 84.33 | 34 | 5.83 | 1 | JR | Phoenix | 8/21/92 |
| 6 | 3 | 97.33 | 21 | 4.58 | 0 | JR | Phoenix | 8/31/92 |
| 6 | 4 | 91.67 | 58 | 7.62 | 2 | JER | Denver | 7/27/92 |
| 6 | 4 | 74.67 | 29 | 5.39 | 0 | JER | Denver | 7/29/92 |
| 6 | 5 | 80.83 | 20 | 4.47 | 0 | KCC | Denver | 7/10/92 |
| 6 | 5 | 80.33 | 19 | 4.36 | 0 | JER | Denver | 7/13/92 |
| 6 | 5 | 81.17 | 14 | 3.74 | 0 | KCC | Denver | 7/14/92 |
| 6 | 5 | 98.33 | 59 | 7.68 | 0 | CJB | Phoenix | 8/12/92 |
| 6 | 5 | 102.33 | 20 | 4.47 | 0 | JR | Phoenix | 8/19/92 |
| 6 | 6 | 65.33 | 16 | 4.00 | 0 | JER | Denver | 7/17/92 |
| 6 | 6 | 83.67 | 34 | 5.83 | 2 | JER | Denver | 7/23/92 |
| 6 | 7 | 81.17 | 44 | 6.63 | 0 | KCC | Denver | 7/09/92 |
| 6 | 7 | 78.00 | 21 | 4.58 | 0 | JER | Denver | 7/20/92 |
| 6 | 7 | 73.67 | 28 | 5.29 | 0 | JER | Denver | 7/30/92 |
| 6 | 7 | 99.83 | 59 | 7.68 | 2 | CJB | Phoenix | 8/14/92 |
| 6 | 7 | 107.67 | 41 | 6.40 | 2 | JR | Phoenix | 8/17/92 |
| 6 | 8 | 84.17 | 51 | 7.14 | 2 | KCC | Denver | 7/13/92 |
| 6 | 8 | 63.00 | 21 | 4.58 | 0 | JER | Denver | 7/16/92 |
| 6 | 8 | 87.00 | 18 | 4.24 | 0 | JR | Phoenix | 8/24/92 |
| 6 | 9 | 68.67 | 50 | 7.07 | 2 | JER | Denver | 7/23/92 |
| 6 | 9 | 86.00 | 34 | 5.83 | 0 | JER | Denver | 7/24/92 |
| 6 | 9 | 81.00 | 20 | 4.47 | 0 | JER | Denver | 7/30/92 |
| 6 | 9 | 90.67 | 19 | 4.36 | 0 | JR | Phoenix | 8/21/92 |
| 6 | 9 | 99.00 | 27 | 5.20 | 0 | JR | Phoenix | 8/31/92 |
| 11 | 1 | 90.33 | 6 | 2.45 | 0 | CPC | Denver | 7/14/92 |
| 11 | 1 | 78.33 | 6 | 2.45 | 0 | CPC | Denver | 7/20/92 |
| 11 | 1 | 102.00 | 9 | 3.00 | 0 | CPC | Phoenix | 8/12/92 |
| 11 | 1 | 96.00 | 8 | 2.83 | 0 | CPC | Phoenix | 8/19/92 |
| 11 | 10 | 76.67 | 5 | 2.24 | 0 | CPC | Denver | 7/24/92 |
| 11 | 10 | 86.93 | 4 | 2.00 | 0 | CPC | Denver | 7/24/92 |
| 11 | 11 | 68.50 | 4 | 2.00 | 0 | CPC | Denver | 7/21/92 |
| 11 | 11 | 79.00 | 4 | 2.00 | 0 | CPC | Denver | 7/22/92 |
| 11 | 11 | 98.67 | 7 | 2.65 | 0 | CPC | Phoenix | 8/18/92 |
| 11 | 11 | 93.67 | 8 | 2.83 | 0 | CPC | Phoenix | 8/20/92 |
| 11 | 12 | 75.33 | 6 | 2.45 | 0 | KCC | Denver | 7/17/92 |
| 11 | 12 | 80.67 | 5 | 2.24 | 0 | CPC | Denver | 7/22/92 |
| 11 | 13 | 85.00 | 4 | 2.00 | 0 | CPC | Denver | 7/11/92 |

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|---|---|---|---|---|---|---|---|---|
| 11 | 13 | 101.33 | 7 | 2.65 | 0 | CPC | Phoenix | 8/13/92 |
| 11 | 13 | 102.00 | 7 | 2.65 | 0 | CPC | Phoenix | 8/17/92 |
| 11 | 13A | 77.67 | 6 | 2.45 | 0 | CPC | Denver | 7/28/92 |
| 11 | 14 | 85.33 | 5 | 2.24 | 0 | CPC | Denver | 7/07/92 |
| 11 | 14 | 63.33 | 7 | 2.65 | 0 | JER | Denver | 7/16/92 |
| 11 | 14 | 66.67 | 5 | 2.24 | 0 | JER | Denver | 7/16/92 |
| 11 | 15 | 79.67 | 7 | 2.65 | 0 | CPC | Denver | 7/21/92 |
| 11 | 16 | 91.00 | 9 | 3.00 | 0 | CPC | Denver | 7/27/92 |
| 11 | 17 | 86.33 | 7 | 2.65 | 0 | CPC | Denver | 7/28/92 |
| 11 | 17 | 105.00 | 8 | 2.83 | 0 | CPC | Phoenix | 8/18/92 |
| 11 | 17 | 100.00 | 8 | 2.83 | 0 | CPC | Phoenix | 8/20/92 |
| 11 | 18 | 80.50 | 6 | 2.45 | 0 | CPC | Denver | 7/21/92 |
| 11 | 18 | 83.67 | 8 | 2.83 | 0 | CPC | Denver | 7/26/92 |
| 11 | 2 | 65.33 | 5 | 2.24 | 0 | JER | Denver | 7/16/92 |
| 11 | 2 | 84.67 | 5 | 2.24 | 0 | CPC | Denver | 7/23/92 |
| 11 | 2 | 81.33 | 7 | 2.65 | 0 | CPC | Phoenix | 8/24/92 |
| 11 | 3 | 80.00 | 6 | 2.45 | 0 | CPC | Denver | 7/26/92 |
| 11 | 3 | 75.67 | 6 | 2.45 | 0 | CPC | Denver | 7/27/92 |
| 11 | 3 | 84.67 | 6 | 2.45 | 0 | CPC | Phoenix | 8/21/92 |
| 11 | 4 | 86.33 | 6 | 2.45 | 0 | CPC | Denver | 7/27/92 |
| 11 | 4 | 75.33 | 7 | 2.65 | 0 | CPC | Denver | 7/29/92 |
| 11 | 5 | 79.27 | 6 | 2.45 | 0 | CPC | Denver | 7/10/92 |
| 11 | 5 | 75.00 | 7 | 2.65 | 0 | CPC | Denver | 7/13/92 |
| 11 | 5 | 103.00 | 6 | 2.45 | 0 | CPC | Phoenix | 8/11/92 |
| 11 | 5 | 102.33 | 7 | 2.65 | 0 | CPC | Phoenix | 8/19/92 |
| 11 | 6 | 66.33 | 4 | 2.00 | 0 | CPC | Denver | 7/17/92 |
| 11 | 6 | 82.00 | 7 | 2.65 | 0 | CPC | Denver | 7/23/92 |
| 11 | 7 | 85.67 | 5 | 2.24 | 0 | CPC | Denver | 7/09/92 |
| 11 | 7 | 72.67 | 6 | 2.45 | 0 | CPC | Denver | 7/20/92 |
| 11 | 7 | 101.00 | 8 | 2.83 | 0 | CPC | Phoenix | 8/14/92 |
| 11 | 7 | 106.67 | 7 | 2.65 | 0 | CPC | Phoenix | 8/17/92 |
| 11 | 8 | 84.00 | 3 | 1.73 | 0 | CPC | Denver | 7/08/92 |
| 11 | 8 | 63.67 | 4 | 2.00 | 0 | JER | Denver | 7/16/92 |
| 11 | 8 | 89.00 | 8 | 2.83 | 0 | CPC | Phoenix | 8/24/92 |
| 11 | 9 | 70.00 | 5 | 2.24 | 0 | CPC | Denver | 7/23/92 |
| 11 | 9 | 91.67 | 5 | 2.24 | 0 | CPC | Denver | 7/24/92 |
| 11 | 9 | 87.67 | 7 | 2.65 | 0 | CPC | Phoenix | 8/21/92 |
| 12 | 1 | 89.67 | 12 | 3.46 | 0 | KCC | Denver | 7/14/92 |
| 12 | 1 | 103.00 | 8 | 2.83 | 0 | JR | Phoenix | 8/11/92 |
| 12 | 13 | 86.33 | 13 | 3.61 | 0 | KCC | Denver | 7/11/92 |
| 12 | 13 | 103.00 | 6 | 2.45 | 0 | JR | Phoenix | 8/13/92 |
| 12 | 14 | 82.50 | 13 | 3.61 | 0 | KCC | Denver | 7/08/92 |
| 12 | 5 | 77.83 | 12 | 3.46 | 0 | KCC | Denver | 7/10/92 |
| 12 | 5 | 75.83 | 6 | 2.45 | 0 | KCC | Denver | 7/13/92 |
| 12 | 5 | 102.67 | 8 | 2.83 | 0 | JR | Phoenix | 8/12/92 |
| 12 | 7 | 85.17 | 12 | 3.46 | 0 | KCC | Denver | 7/09/92 |
| 12 | 7 | 102.33 | 8 | 2.83 | 0 | JR | Phoenix | 8/14/92 |
| 12 | 8 | 81.67 | 6 | 2.45 | 0 | KCC | Denver | 7/07/92 |
| 13 | 1 | 89.33 | 0 | 0.00 | 0 | JER | Denver | 7/14/92 |
| 13 | 1 | 74.00 | 0 | 0.00 | 0 | KCC | Denver | 7/20/92 |
| 13 | 1 | 103.67 | 2 | 1.41 | 0 | CJB | Phoenix | 8/12/92 |
| 13 | 1 | 98.33 | 0 | 0.00 | 0 | CJB | Phoenix | 8/19/92 |
| 13 | 10 | 78.33 | 3 | 1.73 | 0 | KCC | Denver | 7/24/92 |
| 13 | 10 | 91.00 | 3 | 1.73 | 0 | KCC | Denver | 7/24/92 |
| 13 | 11 | 69.33 | 0 | 0.00 | 0 | KCC | Denver | 7/21/92 |
| 13 | 11 | 81.83 | 2 | 1.41 | 0 | KCC | Denver | 7/22/92 |
| 13 | 11 | 100.67 | 0 | 0.00 | 0 | CJB | Phoenix | 8/18/92 |

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|---|---|---|---|---|---|---|---|---|
| 13 | 11 | 95.00 | 2 | 1.41 | 0 | CJB | Phoenix | 8/20/92 |
| 13 | 12 | 78.33 | 2 | 1.41 | 0 | KCC | Denver | 7/22/92 |
| 13 | 13 | 76.00 | 0 | 0.00 | 0 | CPC | Denver | 7/11/92 |
| 13 | 13 | 88.67 | 0 | 0.00 | 0 | CPC | Denver | 7/11/92 |
| 13 | 13 | 103.00 | 1 | 1.00 | 0 | CJB | Phoenix | 8/14/92 |
| 13 | 13 | 105.00 | 3 | 1.73 | 0 | CJB | Phoenix | 8/17/92 |
| 13 | 13A | 78.33 | 2 | 1.41 | 0 | KCC | Denver | 7/28/92 |
| 13 | 13A | 85.33 | 4 | 2.00 | 0 | KCC | Denver | 7/28/92 |
| 13 | 14 | 73.00 | 0 | 0.00 | 0 | CPC | Denver | 7/08/92 |
| 13 | 15 | 79.83 | 0 | 0.00 | 0 | KCC | Denver | 7/21/92 |
| 13 | 16 | 86.67 | 3 | 1.73 | 0 | KCC | Denver | 7/27/92 |
| 13 | 18 | 79.83 | 0 | 0.00 | 0 | KCC | Denver | 7/21/92 |
| 13 | 18 | 80.00 | 3 | 1.73 | 0 | KCC | Denver | 7/26/92 |
| 13 | 2 | 83.00 | 1 | 1.00 | 0 | KCC | Denver | 7/23/92 |
| 13 | 2 | 81.67 | 4 | 2.00 | 0 | CJB | Phoenix | 8/24/92 |
| 13 | 3 | 83.67 | 2 | 1.41 | 0 | KCC | Denver | 7/26/92 |
| 13 | 3 | 74.67 | 0 | 0.00 | 0 | KCC | Denver | 7/27/92 |
| 13 | 3 | 84.33 | 1 | 1.00 | 0 | CJB | Phoenix | 8/21/92 |
| 13 | 4 | 92.67 | 2 | 1.41 | 0 | KCC | Denver | 7/27/92 |
| 13 | 4 | 75.00 | 1 | 1.00 | 0 | KCC | Denver | 7/29/92 |
| 13 | 5 | 80.17 | 0 | 0.00 | 0 | CPC | Denver | 7/10/92 |
| 13 | 5 | 75.33 | 0 | 0.00 | 0 | JER | Denver | 7/13/92 |
| 13 | 5 | 105.00 | 9 | 3.00 | 0 | CJB | Phoenix | 8/11/92 |
| 13 | 6 | 84.67 | 0 | 0.00 | 0 | KCC | Denver | 7/23/92 |
| 13 | 7 | 85.67 | 1 | 1.00 | 0 | CPC | Denver | 7/09/92 |
| 13 | 7 | 80.00 | 0 | 0.00 | 0 | KCC | Denver | 7/20/92 |
| 13 | 7 | 104.67 | 8 | 2.83 | 0 | CJB | Phoenix | 8/13/92 |
| 13 | 7 | 109.83 | 1 | 1.00 | 0 | CJB | Phoenix | 8/17/92 |
| 13 | 8 | 85.00 | 0 | 0.00 | 0 | CPC | Denver | 7/07/92 |
| 13 | 8 | 87.33 | 1 | 1.00 | 0 | CJB | Phoenix | 8/24/92 |
| 13 | 9 | 71.00 | 1 | 1.00 | 0 | KCC | Denver | 7/23/92 |
| 13 | 9 | 87.00 | 2 | 1.41 | 0 | KCC | Denver | 7/24/92 |
| 14 | 1 | 86.33 | 0 | 0.00 | 0 | CPC | Denver | 7/14/92 |
| 14 | 1 | 96.67 | 6 | 2.45 | 0 | CPC | Phoenix | 8/12/92 |
| 14 | 13 | 78.50 | 6 | 2.45 | 0 | KCC | Denver | 7/11/92 |
| 14 | 13 | 95.00 | 5 | 2.24 | 0 | CPC | Phoenix | 8/14/92 |
| 14 | 14 | 83.83 | 4 | 2.00 | 0 | KCC | Denver | 7/13/92 |
| 14 | 5 | 82.50 | 6 | 2.45 | 0 | KCC | Denver | 7/10/92 |
| 14 | 5 | 81.00 | 1 | 1.00 | 0 | CPC | Denver | 7/13/92 |
| 14 | 5 | 104.33 | 6 | 2.45 | 0 | JR | Phoenix | 8/11/92 |
| 14 | 7 | 86.33 | 1 | 1.00 | 0 | KCC | Denver | 7/09/92 |
| 14 | 7 | 97.00 | 2 | 1.41 | 0 | CPC | Phoenix | 8/13/92 |
| 14 | 8 | 73.83 | 6 | 2.45 | 0 | KCC | Denver | 7/08/92 |
| 15 | 1 | 87.17 | 5 | 2.24 | 0 | KCC | Denver | 7/14/92 |
| 15 | 1 | 105.67 | 12 | 3.46 | 0 | JR | Phoenix | 8/11/92 |
| 15 | 13 | 97.00 | 5 | 2.24 | 0 | JR | Phoenix | 8/13/92 |
| 15 | 14 | 83.00 | 2 | 1.41 | 0 | CPC | Denver | 7/13/92 |
| 15 | 15 | 81.67 | 1 | 1.00 | 0 | CPC | Denver | 7/09/92 |
| 15 | 5 | 85.00 | 5 | 2.24 | 0 | CPC | Denver | 7/10/92 |
| 15 | 5 | 81.50 | 5 | 2.24 | 0 | KCC | Denver | 7/13/92 |
| 15 | 5 | 97.67 | 7 | 2.65 | 0 | JR | Phoenix | 8/12/92 |
| 15 | 7 | 80.67 | 1 | 1.00 | 0 | CPC | Denver | 7/11/92 |
| 15 | 7 | 95.67 | 6 | 2.45 | 0 | JR | Phoenix | 8/14/92 |
| 15 | 8 | 81.67 | 7 | 2.65 | 0 | CPC | Denver | 7/08/92 |
| 16 | 1 | 87.67 | 5 | 2.24 | 0 | JER | Denver | 7/14/92 |
| 16 | 1 | 98.33 | 23 | 4.80 | 0 | CJB | Phoenix | 8/12/92 |
| 16 | 13 | 97.67 | 6 | 2.45 | 0 | CJB | Phoenix | 8/14/92 |

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|---|---|---|---|---|---|---|---|---|
| 16 | 14 | 83.83 | 1 | 1.00 | 0 | KCC | Denver | 7/07/92 |
| 16 | 15 | 82.67 | 0 | 0.00 | 0 | KCC | Denver | 7/09/92 |
| 16 | 5 | 86.83 | 0 | 0.00 | 0 | KCC | Denver | 7/10/92 |
| 16 | 5 | 82.17 | 3 | 1.73 | 0 | JER | Denver | 7/13/92 |
| 16 | 5 | 107.33 | 7 | 2.65 | 0 | CJB | Phoenix | 8/11/92 |
| 16 | 7 | 84.33 | 3 | 1.73 | 0 | KCC | Denver | 7/11/92 |
| 16 | 7 | 97.83 | 16 | 4.00 | 0 | CJB | Phoenix | 8/13/92 |
| 16 | 8 | 81.83 | 3 | 1.73 | 0 | KCC | Denver | 7/08/92 |
| 21 | 1 | 88.33 | 7 | 2.65 | 0 | CPC | Denver | 7/14/92 |
| 21 | 1 | 75.67 | 7 | 2.65 | 0 | CPC | Denver | 7/20/92 |
| 21 | 1 | 77.33 | 46 | 6.78 | 0 | CPC | Denver | 7/29/92 |
| 21 | 1 | 103.00 | 51 | 7.14 | 1 | CPC | Phoenix | 8/12/92 |
| 21 | 1 | 101.00 | 77 | 8.77 | 1 | CPC | Phoenix | 8/19/92 |
| 21 | 10 | 74.33 | 13 | 3.61 | 0 | CPC | Denver | 7/24/92 |
| 21 | 10 | 83.33 | 48 | 6.93 | 0 | CPC | Denver | 7/24/92 |
| 21 | 11 | 64.83 | 7 | 2.65 | 0 | CPC | Denver | 7/21/92 |
| 21 | 11 | 81.00 | 15 | 3.87 | 0 | CPC | Denver | 7/22/92 |
| 21 | 11 | 103.67 | 69 | 8.31 | 0 | CPC | Phoenix | 8/18/92 |
| 21 | 11 | 99.00 | 29 | 5.39 | 0 | CPC | Phoenix | 8/20/92 |
| 21 | 12 | 69.67 | 9 | 3.00 | 0 | KCC | Denver | 7/17/92 |
| 21 | 12 | 77.00 | 22 | 4.69 | 0 | CPC | Denver | 7/22/92 |
| 21 | 13 | 103.67 | 34 | 5.83 | 1 | CPC | Phoenix | 8/14/92 |
| 21 | 13 | 106.00 | 43 | 6.56 | 0 | CPC | Phoenix | 8/17/92 |
| 21 | 13A | 74.67 | 45 | 6.71 | 0 | CPC | Denver | 7/28/92 |
| 21 | 13A | 87.00 | 45 | 6.71 | 0 | CPC | Denver | 7/28/92 |
| 21 | 13A | 74.33 | 44 | 6.63 | 0 | CPC | Denver | 7/29/92 |
| 21 | 14 | 83.43 | 30 | 5.48 | 2 | CPC | Denver | 7/08/92 |
| 21 | 14 | 62.67 | 9 | 3.00 | 0 | CPC | Denver | 7/16/92 |
| 21 | 14 | 64.33 | 8 | 2.83 | 0 | CPC | Denver | 7/16/92 |
| 21 | 15 | 86.00 | 14 | 3.74 | 0 | CPC | Denver | 7/09/92 |
| 21 | 15 | 77.00 | 12 | 3.46 | 0 | CPC | Denver | 7/21/92 |
| 21 | 15 | 77.33 | 28 | 5.29 | 0 | CPC | Denver | 7/30/92 |
| 21 | 15 | 99.67 | 31 | 5.57 | 0 | CPC | Phoenix | 8/31/92 |
| 21 | 15 | 91.00 | 15 | 3.87 | 0 | CPC | Phoenix | 9/03/92 |
| 21 | 16 | 89.00 | 39 | 6.24 | 0 | CPC | Denver | 7/27/92 |
| 21 | 16 | 73.00 | 22 | 4.69 | 0 | CPC | Denver | 7/30/92 |
| 21 | 17 | 67.67 | 7 | 2.65 | 0 | CPC | Denver | 7/22/92 |
| 21 | 17 | 84.00 | 32 | 5.66 | 0 | CPC | Denver | 7/28/92 |
| 21 | 17 | 96.33 | 35 | 5.92 | 0 | CPC | Phoenix | 8/18/92 |
| 21 | 17 | 91.67 | 47 | 6.86 | 0 | CPC | Phoenix | 8/20/92 |
| 21 | 18 | 78.67 | 8 | 2.83 | 0 | CPC | Denver | 7/21/92 |
| 21 | 18 | 82.00 | 35 | 5.92 | 0 | CPC | Denver | 7/26/92 |
| 21 | 2 | 66.00 | 12 | 3.46 | 0 | CPC | Denver | 7/16/92 |
| 21 | 2 | 84.33 | 25 | 5.00 | 1 | CPC | Denver | 7/23/92 |
| 21 | 2 | 92.67 | 77 | 8.77 | 1 | CPC | Phoenix | 8/12/92 |
| 21 | 2 | 83.00 | 14 | 3.74 | 0 | CPC | Phoenix | 8/24/92 |
| 21 | 3 | 75.67 | 32 | 5.66 | 0 | CPC | Denver | 7/26/92 |
| 21 | 3 | 69.00 | 27 | 5.20 | 0 | CPC | Denver | 7/27/92 |
| 21 | 3 | 89.00 | 44 | 6.63 | 0 | CPC | Denver | 7/28/92 |
| 21 | 3 | 84.33 | 33 | 5.74 | 0 | CPC | Denver | 7/30/92 |
| 21 | 3 | 86.00 | 62 | 7.87 | 0 | CPC | Phoenix | 8/21/92 |
| 21 | 3 | 93.00 | 22 | 4.69 | 0 | CPC | Phoenix | 8/31/92 |
| 21 | 4 | 83.00 | 44 | 6.63 | 0 | CPC | Denver | 7/27/92 |
| 21 | 4 | 66.33 | 26 | 5.10 | 0 | CPC | Denver | 7/29/92 |
| 21 | 5 | 79.00 | 7 | 2.65 | 0 | CPC | Denver | 7/10/92 |
| 21 | 5 | 76.67 | 9 | 3.00 | 0 | CPC | Denver | 7/13/92 |
| 21 | 5 | 99.67 | 24 | 4.90 | 1 | CPC | Phoenix | 8/11/92 |

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|---|---|---|---|---|---|---|---|---|
| 21 | 5 | 94.67 | 15 | 3.87 | 0 | CPC | Phoenix | 8/19/92 |
| 21 | 6 | 61.50 | 8 | 2.83 | 0 | CPC | Denver | 7/17/92 |
| 21 | 6 | 78.67 | 8 | 2.83 | 0 | CPC | Denver | 7/23/92 |
| 21 | 7 | 84.50 | 7 | 2.65 | 0 | CPC | Denver | 7/11/92 |
| 21 | 7 | 71.00 | 15 | 3.87 | 0 | CPC | Denver | 7/20/92 |
| 21 | 7 | 80.67 | 30 | 5.48 | 0 | CPC | Denver | 7/29/92 |
| 21 | 7 | 103.33 | 28 | 5.29 | 1 | CPC | Phoenix | 8/13/92 |
| 21 | 7 | 99.67 | 40 | 6.32 | 1 | CPC | Phoenix | 8/17/92 |
| 21 | 8 | 84.33 | 117 | 10.82 | 6 | CPC | Denver | 7/07/92 |
| 21 | 8 | 66.00 | 14 | 3.74 | 0 | CPC | Denver | 7/16/92 |
| 21 | 8 | 80.00 | 33 | 5.74 | 0 | CPC | Phoenix | 8/24/92 |
| 21 | 9 | 63.67 | 6 | 2.45 | 0 | CPC | Denver | 7/23/92 |
| 21 | 9 | 87.00 | 18 | 4.24 | 0 | CPC | Denver | 7/24/92 |
| 21 | 9 | 78.67 | 25 | 5.00 | 0 | CPC | Denver | 7/30/92 |
| 21 | 9 | 85.67 | 10 | 3.16 | 0 | CPC | Phoenix | 8/21/92 |
| 21 | 9 | 96.00 | 17 | 4.12 | 0 | CPC | Phoenix | 8/31/92 |
| 22 | 1 | 88.50 | 2 | 1.41 | 0 | KCC | Denver | 7/14/92 |
| 22 | 1 | 99.67 | 2 | 1.41 | 0 | JR | Phoenix | 8/11/92 |
| 22 | 13 | 102.33 | 2 | 1.41 | 0 | JR | Phoenix | 8/14/92 |
| 22 | 14 | 82.00 | 0 | 0.00 | 0 | KCC | Denver | 7/08/92 |
| 22 | 15 | 86.00 | 4 | 2.00 | 0 | KCC | Denver | 7/09/92 |
| 22 | 5 | 79.33 | 3 | 1.73 | 0 | KCC | Denver | 7/10/92 |
| 22 | 5 | 102.00 | 1 | 1.00 | 0 | JR | Phoenix | 8/12/92 |
| 22 | 6 | 63.00 | 2 | 1.41 | 0 | KCC | Denver | 7/17/92 |
| 22 | 7 | 85.67 | 3 | 1.73 | 0 | KCC | Denver | 7/11/92 |
| 22 | 7 | 104.00 | 8 | 2.83 | 0 | JR | Phoenix | 8/13/92 |
| 22 | 8 | 74.33 | 0 | 0.00 | 0 | KCC | Denver | 7/07/92 |
| 23 | 1 | 88.67 | 16 | 4.00 | 0 | JER | Denver | 7/14/92 |
| 23 | 1 | 71.67 | 18 | 4.24 | 0 | KCC | Denver | 7/20/92 |
| 23 | 1 | 80.33 | 48 | 6.93 | 2 | KCC | Denver | 7/29/92 |
| 23 | 1 | 102.83 | 94 | 9.70 | 4 | CJB | Phoenix | 8/12/92 |
| 23 | 1 | 95.33 | 80 | 8.94 | 4 | CJB | Phoenix | 8/19/92 |
| 23 | 10 | 74.83 | 22 | 4.69 | 0 | KCC | Denver | 7/24/92 |
| 23 | 10 | 90.00 | 46 | 6.78 | 1 | KCC | Denver | 7/24/92 |
| 23 | 11 | 65.00 | 10 | 3.16 | 0 | KCC | Denver | 7/21/92 |
| 23 | 11 | 80.00 | 19 | 4.36 | 0 | KCC | Denver | 7/22/92 |
| 23 | 11 | 96.67 | 78 | 8.83 | 4 | CJB | Phoenix | 8/18/92 |
| 23 | 11 | 92.00 | 112 | 10.58 | 6 | CJB | Phoenix | 8/20/92 |
| 23 | 12 | 71.00 | 36 | 6.00 | 1 | JER | Denver | 7/17/92 |
| 23 | 12 | 81.67 | 27 | 5.20 | 0 | KCC | Denver | 7/22/92 |
| 23 | 13 | 102.67 | 74 | 8.60 | 4 | CJB | Phoenix | 8/13/92 |
| 23 | 13 | 101.50 | 76 | 8.72 | 4 | CJB | Phoenix | 8/17/92 |
| 23 | 13A | 76.00 | 30 | 5.48 | 0 | KCC | Denver | 7/28/92 |
| 23 | 13A | 85.33 | 40 | 6.32 | 0 | KCC | Denver | 7/28/92 |
| 23 | 13A | 78.00 | 36 | 6.00 | 0 | KCC | Denver | 7/29/92 |
| 23 | 14 | 75.33 | 30 | 5.48 | 0 | CPC | Denver | 7/08/92 |
| 23 | 14 | 63.17 | 20 | 4.47 | 0 | KCC | Denver | 7/16/92 |
| 23 | 15 | 85.67 | 22 | 4.69 | 0 | CPC | Denver | 7/09/92 |
| 23 | 15 | 78.00 | 23 | 4.80 | 0 | KCC | Denver | 7/21/92 |
| 23 | 15 | 82.67 | 36 | 6.00 | 0 | KCC | Denver | 7/30/92 |
| 23 | 15 | 98.00 | 58 | 7.62 | 2 | CJB | Phoenix | 8/31/92 |
| 23 | 15 | 91.67 | 51 | 7.14 | 2 | CJB | Phoenix | 9/03/92 |
| 23 | 16 | 82.50 | 24 | 4.90 | 0 | KCC | Denver | 7/27/92 |
| 23 | 16 | 72.00 | 24 | 4.90 | 0 | KCC | Denver | 7/30/92 |
| 23 | 17 | 68.33 | 16 | 4.00 | 0 | KCC | Denver | 7/22/92 |
| 23 | 17 | 87.00 | 36 | 6.00 | 0 | KCC | Denver | 7/28/92 |
| 23 | 17 | 104.17 | 78 | 8.83 | 4 | CJB | Phoenix | 8/18/92 |

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|---|---|---|---|---|---|---|---|---|
| 23 | 17 | 99.50 | 66 | 8.12 | 2 | CJB | Phoenix | 8/20/92 |
| 23 | 18 | 80.33 | 30 | 5.48 | 0 | KCC | Denver | 7/21/92 |
| 23 | 18 | 77.00 | 28 | 5.29 | 0 | KCC | Denver | 7/26/92 |
| 23 | 2 | 67.67 | 20 | 4.47 | 0 | KCC | Denver | 7/16/92 |
| 23 | 2 | 79.33 | 62 | 7.87 | 3 | KCC | Denver | 7/23/92 |
| 23 | 2 | 91.00 | 66 | 8.12 | 2 | JR | Phoenix | 8/12/92 |
| 23 | 2 | 81.67 | 120 | 10.95 | 5 | CJB | Phoenix | 8/24/92 |
| 23 | 3 | 81.33 | 48 | 6.93 | 2 | KCC | Denver | 7/26/92 |
| 23 | 3 | 71.67 | 30 | 5.48 | 0 | KCC | Denver | 7/27/92 |
| 23 | 3 | 80.67 | 32 | 5.66 | 0 | KCC | Denver | 7/30/92 |
| 23 | 3 | 84.83 | 74 | 8.60 | 4 | CJB | Phoenix | 8/21/92 |
| 23 | 3 | 100.00 | 58 | 7.62 | 4 | CJB | Phoenix | 8/31/92 |
| 23 | 4 | 88.33 | 56 | 7.48 | 2 | KCC | Denver | 7/27/92 |
| 23 | 4 | 66.67 | 24 | 4.90 | 0 | KCC | Denver | 7/29/92 |
| 23 | 5 | 81.50 | 27 | 5.20 | 0 | CPC | Denver | 7/10/92 |
| 23 | 5 | 78.00 | 15 | 3.87 | 0 | JER | Denver | 7/13/92 |
| 23 | 5 | 101.00 | 93 | 9.64 | 4 | CJB | Phoenix | 8/11/92 |
| 23 | 5 | 101.17 | 80 | 8.94 | 4 | CJB | Phoenix | 8/19/92 |
| 23 | 6 | 65.50 | 15 | 3.87 | 0 | KCC | Denver | 7/17/92 |
| 23 | 6 | 83.33 | 49 | 7.00 | 1 | KCC | Denver | 7/23/92 |
| 23 | 7 | 78.33 | 15 | 3.87 | 0 | CPC | Denver | 7/11/92 |
| 23 | 7 | 78.33 | 23 | 4.80 | 0 | KCC | Denver | 7/20/92 |
| 23 | 7 | 73.67 | 18 | 4.24 | 0 | KCC | Denver | 7/29/92 |
| 23 | 7 | 103.33 | 58 | 7.62 | 0 | CJB | Phoenix | 8/14/92 |
| 23 | 7 | 106.67 | 76 | 8.72 | 4 | CJB | Phoenix | 8/17/92 |
| 23 | 8 | 79.50 | 26 | 5.10 | 0 | CPC | Denver | 7/07/92 |
| 23 | 8 | 63.17 | 16 | 4.00 | 0 | KCC | Denver | 7/16/92 |
| 23 | 8 | 65.17 | 15 | 3.87 | 0 | KCC | Denver | 7/16/92 |
| 23 | 8 | 83.00 | 82 | 9.06 | 5 | CJB | Phoenix | 8/24/92 |
| 23 | 9 | 65.00 | 19 | 4.36 | 0 | KCC | Denver | 7/23/92 |
| 23 | 9 | 84.33 | 42 | 6.48 | 0 | KCC | Denver | 7/24/92 |
| 23 | 9 | 77.33 | 18 | 4.24 | 0 | KCC | Denver | 7/30/92 |
| 23 | 9 | 86.00 | 62 | 7.87 | 2 | CJB | Phoenix | 8/21/92 |
| 23 | 9 | 92.33 | 68 | 8.25 | 4 | CJB | Phoenix | 8/31/92 |
| 24 | 1 | 87.33 | 23 | 4.80 | 0 | CPC | Denver | 7/14/92 |
| 24 | 1 | 75.00 | 19 | 4.36 | 0 | JER | Denver | 7/20/92 |
| 24 | 1 | 74.00 | 38 | 6.16 | 0 | JER | Denver | 7/29/92 |
| 24 | 1 | 106.00 | 10 | 3.16 | 0 | CPC | Phoenix | 8/11/92 |
| 24 | 1 | 101.67 | 37 | 6.08 | 0 | JR | Phoenix | 8/19/92 |
| 24 | 10 | 75.33 | 25 | 5.00 | 0 | JER | Denver | 7/24/92 |
| 24 | 10 | 84.33 | 13 | 3.61 | 0 | JER | Denver | 7/24/92 |
| 24 | 11 | 67.33 | 5 | 2.24 | 0 | JER | Denver | 7/21/92 |
| 24 | 11 | 81.00 | 25 | 5.00 | 0 | JER | Denver | 7/22/92 |
| 24 | 11 | 105.00 | 44 | 6.63 | 0 | JR | Phoenix | 8/18/92 |
| 24 | 11 | 99.00 | 50 | 7.07 | 0 | JR | Phoenix | 8/20/92 |
| 24 | 12 | 70.33 | 6 | 2.45 | 0 | CPC | Denver | 7/17/92 |
| 24 | 12 | 79.33 | 13 | 3.61 | 0 | JER | Denver | 7/22/92 |
| 24 | 13 | 99.00 | 16 | 4.00 | 0 | CPC | Phoenix | 8/14/92 |
| 24 | 13 | 106.67 | 32 | 5.66 | 0 | JR | Phoenix | 8/17/92 |
| 24 | 13A | 76.00 | 25 | 5.00 | 0 | JER | Denver | 7/28/92 |
| 24 | 13A | 87.33 | 31 | 5.57 | 0 | JER | Denver | 7/28/92 |
| 24 | 13A | 80.33 | 38 | 6.16 | 0 | JER | Denver | 7/29/92 |
| 24 | 14 | 77.67 | 26 | 5.10 | 0 | KCC | Denver | 7/08/92 |
| 24 | 15 | 86.67 | 14 | 3.74 | 0 | KCC | Denver | 7/09/92 |
| 24 | 15 | 78.00 | 31 | 5.57 | 0 | JER | Denver | 7/21/92 |
| 24 | 15 | 81.33 | 38 | 6.16 | 0 | JER | Denver | 7/30/92 |
| 24 | 15 | 92.33 | 44 | 6.63 | 0 | JR | Phoenix | 8/31/92 |

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|---|---|---|---|---|---|---|---|---|
| 24 | 15 | 92.00 | 38 | 6.16 | 0 | JR | Phoenix | 9/03/92 |
| 24 | 16 | 85.00 | 31 | 5.57 | 0 | JER | Denver | 7/27/92 |
| 24 | 16 | 71.67 | 32 | 5.66 | 0 | JER | Denver | 7/30/92 |
| 24 | 17 | 68.83 | 25 | 5.00 | 0 | JER | Denver | 7/22/92 |
| 24 | 17 | 85.67 | 25 | 5.00 | 0 | JER | Denver | 7/28/92 |
| 24 | 17 | 98.67 | 38 | 6.16 | 0 | JR | Phoenix | 8/18/92 |
| 24 | 17 | 92.67 | 44 | 6.63 | 0 | JR | Phoenix | 8/20/92 |
| 24 | 17 | 91.00 | 52 | 7.21 | 3 | JR | Phoenix | 8/20/92 |
| 24 | 18 | 77.67 | 6 | 2.45 | 0 | JER | Denver | 7/21/92 |
| 24 | 18 | 82.33 | 30 | 5.48 | 0 | JER | Denver | 7/26/92 |
| 24 | 2 | 83.33 | 13 | 3.61 | 0 | JER | Denver | 7/23/92 |
| 24 | 2 | 84.33 | 38 | 6.16 | 0 | JR | Phoenix | 8/24/92 |
| 24 | 3 | 77.67 | 63 | 7.94 | 3 | JER | Denver | 7/26/92 |
| 24 | 3 | 70.67 | 24 | 4.90 | 0 | JER | Denver | 7/27/92 |
| 24 | 3 | 89.67 | 31 | 5.57 | 0 | JER | Denver | 7/28/92 |
| 24 | 3 | 78.67 | 32 | 5.66 | 0 | JER | Denver | 7/30/92 |
| 24 | 3 | 87.00 | 44 | 6.63 | 0 | JR | Phoenix | 8/21/92 |
| 24 | 3 | 98.67 | 38 | 6.16 | 0 | JR | Phoenix | 8/31/92 |
| 24 | 4 | 91.00 | 31 | 5.57 | 0 | JER | Denver | 7/27/92 |
| 24 | 4 | 67.00 | 19 | 4.36 | 0 | JER | Denver | 7/29/92 |
| 24 | 5 | 84.17 | 26 | 5.10 | 0 | KCC | Denver | 7/10/92 |
| 24 | 5 | 80.67 | 16 | 4.00 | 0 | CPC | Denver | 7/13/92 |
| 24 | 5 | 99.67 | 10 | 3.16 | 0 | CPC | Phoenix | 8/12/92 |
| 24 | 5 | 96.67 | 38 | 6.16 | 0 | JR | Phoenix | 8/19/92 |
| 24 | 6 | 63.50 | 16 | 4.00 | 0 | JER | Denver | 7/17/92 |
| 24 | 6 | 82.00 | 19 | 4.36 | 0 | JER | Denver | 7/23/92 |
| 24 | 7 | 80.17 | 38 | 6.16 | 0 | KCC | Denver | 7/11/92 |
| 24 | 7 | 72.67 | 23 | 4.80 | 0 | JER | Denver | 7/20/92 |
| 24 | 7 | 78.67 | 32 | 5.66 | 0 | JER | Denver | 7/29/92 |
| 24 | 7 | 99.33 | 22 | 4.69 | 0 | CPC | Phoenix | 8/13/92 |
| 24 | 7 | 101.33 | 45 | 6.71 | 0 | JR | Phoenix | 8/17/92 |
| 24 | 8 | 84.50 | 19 | 4.36 | 0 | KCC | Denver | 7/13/92 |
| 24 | 8 | 79.67 | 44 | 6.63 | 0 | JR | Phoenix | 8/24/92 |
| 24 | 9 | 65.33 | 25 | 5.00 | 0 | JER | Denver | 7/23/92 |
| 24 | 9 | 90.33 | 13 | 3.61 | 0 | JER | Denver | 7/24/92 |
| 24 | 9 | 82.67 | 38 | 6.16 | 0 | JER | Denver | 7/30/92 |
| 24 | 9 | 84.67 | 50 | 7.07 | 0 | JR | Phoenix | 8/21/92 |
| 24 | 9 | 100.33 | 46 | 6.78 | 1 | JR | Phoenix | 8/31/92 |
| 25 | 1 | 85.33 | 14 | 3.74 | 0 | KCC | Denver | 7/14/92 |
| 25 | 1 | 100.33 | 23 | 4.80 | 0 | JR | Phoenix | 8/12/92 |
| 25 | 13 | 85.27 | 17 | 4.12 | 0 | CPC | Denver | 7/11/92 |
| 25 | 13 | 101.00 | 24 | 4.90 | 0 | JR | Phoenix | 8/13/92 |
| 25 | 14 | 82.77 | 16 | 4.00 | 0 | CPC | Denver | 7/08/92 |
| 25 | 14 | 84.33 | 20 | 4.47 | 0 | CPC | Denver | 7/13/92 |
| 25 | 2 | 94.00 | 32 | 5.66 | 0 | CJB | Phoenix | 8/12/92 |
| 25 | 5 | 85.50 | 12 | 3.46 | 0 | CPC | Denver | 7/10/92 |
| 25 | 5 | 82.50 | 1 | 1.00 | 0 | KCC | Denver | 7/13/92 |
| 25 | 5 | 106.67 | 31 | 5.57 | 0 | CPC | Phoenix | 8/11/92 |
| 25 | 7 | 84.00 | 4 | 2.00 | 0 | CPC | Denver | 7/09/92 |
| 25 | 7 | 100.00 | 15 | 3.87 | 0 | JR | Phoenix | 8/14/92 |
| 26 | 1 | 86.83 | 21 | 4.58 | 0 | JER | Denver | 7/14/92 |
| 26 | 1 | 106.00 | 51 | 7.14 | 0 | CJB | Phoenix | 8/11/92 |
| 26 | 13 | 83.33 | 5 | 2.24 | 0 | KCC | Denver | 7/11/92 |
| 26 | 13 | 101.00 | 27 | 5.20 | 0 | CJB | Phoenix | 8/14/92 |
| 26 | 14 | 83.33 | 6 | 2.45 | 0 | KCC | Denver | 7/08/92 |
| 26 | 5 | 82.67 | 2 | 1.41 | 0 | KCC | Denver | 7/10/92 |
| 26 | 5 | 82.17 | 5 | 2.24 | 0 | JER | Denver | 7/13/92 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 26 | 5 | 101.67 | 16 | 4.00 | 0 | CJB | Phoenix | 8/12/92 |
| 26 | 7 | 83.67 | 13 | 3.61 | 0 | KCC | Denver | 7/09/92 |
| 26 | 7 | 101.00 | 15 | 3.87 | 0 | CJB | Phoenix | 8/13/92 |
| 26 | 8 | 84.83 | 0 | 0.00 | 0 | KCC | Denver | 7/07/92 |
| 31 | 1 | 88.33 | 3 | 1.73 | 0 | CPC | Denver | 7/14/92 |
| 31 | 1 | 78.33 | 11 | 3.32 | 0 | JER | Denver | 7/20/92 |
| 31 | 1 | 108.67 | 5 | 2.24 | 0 | CPC | Phoenix | 8/11/92 |
| 31 | 10 | 77.33 | 6 | 2.45 | 0 | JER | Denver | 7/24/92 |
| 31 | 10 | 87.00 | 5 | 2.24 | 0 | JER | Denver | 7/24/92 |
| 31 | 11 | 70.33 | 3 | 1.73 | 0 | JER | Denver | 7/21/92 |
| 31 | 11 | 78.00 | 6 | 2.45 | 0 | JER | Denver | 7/22/92 |
| 31 | 12 | 80.33 | 5 | 2.24 | 0 | JER | Denver | 7/22/92 |
| 31 | 13 | 89.17 | 5 | 2.24 | 0 | CPC | Denver | 7/11/92 |
| 31 | 13 | 105.33 | 7 | 2.65 | 0 | CPC | Phoenix | 8/14/92 |
| 31 | 13 | 109.33 | 4 | 2.00 | 0 | JR | Phoenix | 8/17/92 |
| 31 | 13A | 78.67 | 6 | 2.45 | 0 | JER | Denver | 7/28/92 |
| 31 | 14 | 83.50 | 5 | 2.24 | 0 | CPC | Denver | 7/07/92 |
| 31 | 15 | 78.67 | 4 | 2.00 | 0 | JER | Denver | 7/21/92 |
| 31 | 16 | 92.67 | 5 | 2.24 | 0 | JER | Denver | 7/27/92 |
| 31 | 17 | 86.67 | 5 | 2.24 | 0 | JER | Denver | 7/28/92 |
| 31 | 17 | 101.67 | 4 | 2.00 | 0 | JR | Phoenix | 8/18/92 |
| 31 | 17 | 95.67 | 6 | 2.45 | 0 | JR | Phoenix | 8/20/92 |
| 31 | 18 | 80.00 | 4 | 2.00 | 0 | JER | Denver | 7/21/92 |
| 31 | 18 | 85.33 | 4 | 2.00 | 0 | JER | Denver | 7/26/92 |
| 31 | 2 | 89.00 | 6 | 2.45 | 0 | JR | Phoenix | 8/24/92 |
| 31 | 3 | 79.67 | 4 | 2.00 | 0 | JER | Denver | 7/26/92 |
| 31 | 3 | 77.00 | 4 | 2.00 | 0 | JER | Denver | 7/27/92 |
| 31 | 4 | 89.00 | 5 | 2.24 | 0 | JER | Denver | 7/27/92 |
| 31 | 4 | 75.00 | 4 | 2.00 | 0 | JER | Denver | 7/29/92 |
| 31 | 5 | 80.33 | 4 | 2.00 | 0 | CPC | Denver | 7/10/92 |
| 31 | 5 | 83.17 | 6 | 2.45 | 0 | CPC | Denver | 7/13/92 |
| 31 | 5 | 105.00 | 5 | 2.24 | 0 | CPC | Phoenix | 8/12/92 |
| 31 | 5 | 97.00 | 7 | 2.65 | 0 | JR | Phoenix | 8/19/92 |
| 31 | 6 | 82.67 | 5 | 2.24 | 0 | JER | Denver | 7/23/92 |
| 31 | 7 | 85.67 | 5 | 2.24 | 0 | CPC | Denver | 7/09/92 |
| 31 | 7 | 73.33 | 2 | 1.41 | 0 | JER | Denver | 7/20/92 |
| 31 | 7 | 105.00 | 4 | 2.00 | 0 | CPC | Phoenix | 8/13/92 |
| 31 | 7 | 105.33 | 4 | 2.00 | 0 | JR | Phoenix | 8/17/92 |
| 31 | 8 | 77.00 | 5 | 2.24 | 0 | CPC | Denver | 7/08/92 |
| 31 | 8 | 82.00 | 6 | 2.45 | 0 | JR | Phoenix | 8/24/92 |
| 31 | 9 | 71.00 | 5 | 2.24 | 0 | JER | Denver | 7/23/92 |
| 31 | 9 | 90.00 | 4 | 2.00 | 0 | JER | Denver | 7/24/92 |
| 31 | 9 | 85.33 | 5 | 2.24 | 0 | JR | Phoenix | 8/21/92 |
| 32 | 1 | 87.83 | 4 | 2.00 | 0 | KCC | Denver | 7/14/92 |
| 32 | 1 | 104.67 | 5 | 2.24 | 0 | JR | Phoenix | 8/12/92 |
| 32 | 13 | 89.33 | 3 | 1.73 | 0 | KCC | Denver | 7/11/92 |
| 32 | 13 | 105.00 | 5 | 2.24 | 0 | JR | Phoenix | 8/13/92 |
| 32 | 14 | 84.83 | 0 | 0.00 | 0 | KCC | Denver | 7/07/92 |
| 32 | 5 | 80.33 | 3 | 1.73 | 0 | KCC | Denver | 7/10/92 |
| 32 | 5 | 83.00 | 3 | 1.73 | 0 | KCC | Denver | 7/13/92 |
| 32 | 5 | 108.33 | 8 | 2.83 | 0 | JR | Phoenix | 8/11/92 |
| 32 | 7 | 85.17 | 3 | 1.73 | 0 | KCC | Denver | 7/09/92 |
| 32 | 7 | 106.00 | 8 | 2.83 | 0 | CJB | Phoenix | 8/14/92 |
| 32 | 8 | 77.67 | 0 | 0.00 | 0 | KCC | Denver | 7/08/92 |

# APPENDIX I

# FORMULAE FOR CALCULATION OF TOTAL WEIGHTED DEMERITS AND OCCURRENCE OF MAJOR (DRIVEABILITY) MALFUNCTIONS

## OCCURRENCE OF MAJOR (DRIVEABILITY) MALFUNCTIONS

## CALCULATION SYSTEM

The Scale of Occurrence of Major (Driveability) Malfunctions (OMM) is a measure of major malfunctions and stalls. It is a weighted sum of heavy stumbles, surges, and hesitations, drive stalls and idle stalls. Idle stalls are weighted by 1. Drive stalls, heavy stumble, heavy surge, and heavy hesitation are weighted by 2. Trace and medium malfunctions are weighted by 0, as is starting time. As with TWD, only one malfunction per maneuver is counted.

## TOTAL WEIGHTED DEMERIT CALCULATION SYSTEM

A numerical value for driveability during the CRC test is obtained by assigning demerits to operating malfunctions. Depending upon the type of malfunction, demerits are assigned in various ways. Demerits for poor starting are obtained by subtracting two seconds from the measured starting time. The number of stalls which occur during idle as well as during driving maneuvers are counted separately and assigned demerits. The multiplying x factors of 8 and 32 for idle and maneuvering stalls, respectively, account for the fact that stalls are very undesirable, especially during car maneuvers.

Other malfunctions, such as hesitation, stumble, surge, idle roughness, and backfire, are rated subjectively by the driver on a scale of trace, moderate, or heavy. For these malfunctions, a certain number of demerits is assigned to each of the subjective ratings. However, since all malfunctions are not of equal importance, the demerits are multiplied by the weighting factors to yield weighted demerits.

Finally, weighted demerits, demerits for stalls, and demerits for poor starting are summed to obtain total weighted demerits (TWD), which are used as an indication of driveability during the test. As driveability deteriorates, TWD increases.

A restriction is applied in the totaling of demerits to insure that a stall results in the highest possible number of demerits within a given maneuver. When more than one malfunction occurs during a maneuver, demerits are counted for only the malfunction which had the largest number of weighted demerits. Another restriction is that for each idle period, no more than 3 idle stalls are counted.

# APPENDIX J

## RESULTS USING SQUARE ROOT OF TOTAL WEIGHTED DEMERITS

# Root-TWD by RVP and Altitude for Carb Cars

| Altitude | Temperature ( $^0F$) | RVP (psi) | Significant effects | Magnitude of effect ($TWD^{.5}$) | Mean ($TWD^{.5}$) | RMSE[1] ($TWD^{.5}$) | Confidence level | $r^2$ for correlation |
|---|---|---|---|---|---|---|---|---|
| high | ≤80 | 7.5 | $T_{50}$ | $-0.52/20^oF^2$ | 6.28 | 1.13 | 99% | 0.80 |
| high | ≥80 | 7.5 | Temperature<br>$T_{50}$ | $1.0/10^oF^3$<br>$-0.69/20^oF$ | 7.16 | 1.22 | 93%<br>99.8% | 0.74 |
| low | ≥90 | 7.5 | Temperature | $1.8/10^oF$ | 7.87 | 1.25 | 99.99% | 0.84 |
| high | ≤80 | 11.5 | Temperature | $1.8/10^oF$ | 6.87 | 1.12 | 99.99% | 0.76 |
| high | ≥80 | 11.5 | Temperature<br>Oxygenate | $1.5/10^oF$<br>0.94 HC[4] | 8.69 | 1.07 | 99%<br>96% | 0.72 |

[1] Root mean square error
[2] Indicates that driveability improves with increasing $T_{50}$
[3] Indicates that driveability degrades with increasing ambient temperature
[4] Indicates that hydrocarbon fuels perform worse than both 15% MTBE and 10% ethanol blends

# Root-TWD by RVP and Altitude for Injected Cars

| Altitude | Temperature ( $^0F$) | RVP (psi) | Significant effects | Magnitude of effect ($TWD^{.5}$) | Mean ($TWD^{.5}$) | RMSE[1] ($TWD^{.5}$) | Confidence level | $r^2$ for correlation |
|---|---|---|---|---|---|---|---|---|
| high | ≤80 | 7.5 | $T_{50}$ | $-0.47/20^oF^2$ | 3.5 | 0.96 | 99% | 0.80 |
| high | ≥80 | 7.5 | none | | 3.3 | 1.01 | | 0.81 |
| low | ≥90 | 7.5 | none | | 4.8 | 0.98 | | 0.88 |
| high | ≤80 | 11.5 | Temperature | $0.71/10^oF^3$ | 3.4 | 0.78 | 99% | 0.78 |
| high | ≥80 | 11.5 | none | | 3.5 | 1.12 | | 0.85 |

[1] Root mean square error
[2] Indicates that driveability improves with increasing $T_{50}$
[3] Indicates that driveability degrades with increasing ambient temperature